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SOME ACCOUNT OF THE METEOROLOGICAL WORK OF THE LATE JAMES GLAISHER, F.R.S.

BY WILLIAM MARRIOTT, F.R.Met.Soc.

(Plates I. and II.)

[Read December 16, 1903.]

I HAVE already written a memoir of the late Mr. James Glaisher, F.R.S., which appeared in the *Quarterly Journal* for April 1903, so it seems hardly necessary for any further reference to be made to him. But since that time a number of his books and pamphlets, as well as the instruments used by him in his famous balloon ascents, have, by the courtesy of his son, Dr. J. W. L. Glaisher, F.R.S., come into the possession of the Royal Meteorological Society. The Council were desirous that these instruments should be exhibited at one of the Meetings of the Society, and they also requested me at the same time to give some account of Mr. Glaisher's Meteorological Work. I could not refuse this request, as Mr. Glaisher was my old chief at the Royal Observatory, Greenwich, and also because I think there are many Fellows who know but little about him and the great obligation we are under to him for having founded this Society.

JAMES GLAISHER was born on April 7, 1809. In 1829 and 1830 he was engaged in Ireland on the principal triangulation of the Trigonometrical Survey. In 1833 he was appointed by Prof. Airy as assistant at the Cambridge Observatory. On December 4, 1835, Prof. Airy (then Astronomer-Royal) appointed him an assistant at the Royal Observatory, Greenwich. On the establishment of the Magnetical and Meteorological Department in November 1840, Mr. Glaisher was transferred thereto from the Astronomical Department and appointed Superintendent. He held this post until his retirement in 1874. He subsequently removed from Blackheath to South Croydon, where he resided until his death on February 7, 1903, at the advanced age of 93 years.

I have compiled, with the help of Mr. W. J. Marriott, a bibliographical list of Mr. Glaisher's published meteorological works and papers, which is given in the Appendix, p. 22. These extend from 1847 to 1902.

I now propose to give a brief summary of some of the principal meteorological works and investigations on which Mr. Glaisher was engaged.

Radiation at Night.

The first published paper by Mr. Glaisher was "On the Amount of Radiation of Heat, at Night, from the Earth, and from various Bodies placed on or near the Surface of the Earth," which appeared in the *Philosophical Transactions* for 1847. In this he says that, as soon as his duties of the Magnetical and Meteorological Observatory permitted, he employed some time in making himself acquainted with all that was known upon the subject of radiation. He found that there was a great want of good observations, and therefore determined to pursue the subject with some degree of steadiness. As he found it difficult to obtain reliable and suitable instruments, he consulted Mr. Watkins, the optician, in 1842, on the subject, and induced him to make a special set of thermometers for the purpose. The essentials laid down for their construction were: (1) that the points corresponding to the freezing and boiling of water be exactly determined; (2) that the column of mercury which fills the tube be exactly uniform throughout; (3) that the thermometers should be of the most delicate kind, and the most sensitive to the variations of heat; and (4) that the scale be marked on the tube. He had in all 25 mercurial thermometers and 25 self-registering minimum thermometers. These were all carefully tested and compared together prior to use. The experiments, which extended over three years, were carried on in a railed-off enclosure within the grounds of the Royal Observatory, and Mr. Glaisher was greatly assisted in the taking of the observations by the staff in his department. The thermometers were placed on various bodies on or near the surface of the earth: on long and short grass, mould, cotton-wool of various colours, flannel, wood, and other substances. The following figures show the relative radiating power of a few of the substances, that of long grass being considered as 1000:—

Hare-skin	1316	Lamp Black in powder	961
Rabbit-skin	1240	Flannel	871
White Raw Wool	1222	Glass	864
Flax	1186	Copper	839
Raw Silk	1107	Iron	642
Unwrought White Cotton Wool	1085	Slate	573
Silk from the cocoon	1034	Garden Mould	472
Long Grass	1000	Gravel	288

The formation of dew was found to depend solely on the temperatures of the bodies upon which it was deposited, and it never appeared upon them till their temperatures had descended below that of the dew-point in their locality, as found by observations of a dry and wet-bulb thermometer placed in their vicinity.

Returns for the Registrar-General.

At the request of the Registrar-General, Mr. Glaisher about 1846 began to take steps to collect Meteorological Observations for inclusion in the *Quarterly Returns of Marriages, Births, and Deaths.* He induced a number of gentlemen to equip meteorological stations, and visited many of them, testing the instruments and giving instruction in the method of observing in order to secure as much uniformity as possible. With the year 1847 he commenced his "Remarks on the Weather during the Quarter," which have been a prominent feature in these Returns ever since.

It may be interesting to give Mr. Glaisher's own account as to the manner in which his first connection with the Registrar-General commenced. In his evidence before the Royal Commission on Scientific Instruction in 1874, he said: "The Registrar-General had published the mean temperature at York as being five degrees higher than the mean temperature at London; in consequence of which I wrote to him telling him of the physical impossibility of such being the case, and he then told me that he had no one in his office who could reduce the observations, and no one who could prove whether they were correct or no. Having been educated as an astronomer, and having had the Meteorological Department placed in my hands, I had been desirous of ascertaining the general accuracy of meteorological instruments in general use. For that purpose I had gone all over England, Ireland, and Scotland to see the best observers who were taking observations, and I found that of the thermometers the most accurate were three-tenths of a degree wrong at 32°, and three degrees wrong at 90°, in both cases reading too high, and that barometers were very frequently a quarter of an inch in error. Mr. Sheepshanks, in the years 1840 and 1841 brought out his standard thermometer, which is still the standard, and I endeavoured to bring into general use instruments very nearly free from errors. The instrument-makers then worked with me, and the consequence was, that at the time the Registrar-General spoke to me, I knew a large number of persons who, I thought, would take observations; and, knowing a good number of Cambridge men, I thought that clergymen would unite with me, and would help in establishing a system of truthful observations. Thereupon I travelled over the country and induced some 50 or 60 gentlemen of education and position to engage in the toilsome work of daily observations, and they have done so for these 30 years. I feel it a great pleasure and pride to think that I have successfully organised a system which had always previously failed. That system I have continued from that time to the present."

Mr. Glaisher continued to supply these Quarterly Reports on "The Meteorology of England" to the Registrar-General up to March 1902. He also furnished a yearly statement for the Annual Reports of the Registrar-General.

In addition to the above, he contributed articles on "The Meteorology of England" for some time, both quarterly and yearly, to the *Philosophical Magazine* and other journals. At the end of the report for 1847 he said: "In conclusion, I have merely to remark, that I am persuaded the spirit of the above method of reducing meteorological observations,

and deducing from them general formulæ, will some day lead to empirical laws, showing the reciprocal dependence of each subject of research. I would, however, impress upon observers generally the absolute necessity of using good instruments, and ascertaining their errors by comparison with standards; such would save me a great deal of labour and anxiety, which I have experienced in the past year. These exertions, it is evident, could not be long continued; and it must be borne in mind that no system of calculation can deduce good results from imperfect observations. I must beg, however, to offer my sincere thanks to the gentlemen who have furnished the observations, for their ready aquiescence at all times to my wishes.

"This is the first Annual Report upon the meteorology of England. May it be followed by many, more ably conducted and more valuable to meteorology!"

Corrections for Diurnal Range.

As Mr. Glaisher began to collect meteorological statistics from various places, he soon found that, apart from the reliability of the instruments employed, the observations were not comparable with each other, as the readings were made at different hours, and so gave different results. When the Magnetical and Meteorological Department at the Royal Observatory, Greenwich, was established, it was the custom to take observations every two hours, day and night. Mr. Glaisher was soon impressed with the diurnal range in the various elements, and that readings were above or below the mean for the day according to the hour at which they were taken. And so, when five years' observations had been made, he prepared his "Corrections to be applied to the Monthly Means of Meteorological Observations taken at any Hour, to convert them into Mean Monthly Values." These corrections he recommended to his observers all over the country, and he employed them himself in working up the results for the Registrar-General.

It should be said that these corrections were based on the Greenwich observations, and could hardly be applicable to all places, especially coast stations. However, they were the means of making observations more comparable with each other than had been possible previously.

Hygrometrical Tables.

Mr. Glaisher early directed his attention to the most effective and simple method of determining the true hygrometric conditions of the air. He held this to be best performed by the employment of the dry- and wet-bulb thermometers, and which were found to give results identical with Daniell's hygrometer, over which they possess the great advantage of requiring water only, and giving continuous observations. Upon the results of his simultaneous determinations of the temperature of the dew-point by Daniell's hygrometer and the dry- and wet-bulb thermometers he compiled and published in 1847 his *Hygrometrical Tables adapted to the use of the Dry- and Wet-bulb Thermometer*, which have been, and still are, the accepted authority by British meteorologists for hygrometrical reductions. These Tables have now reached their ninth edition.

Thermometrical Observations, 1771 *to* 1849.

After Mr. Glaisher had compiled his Corrections for Diurnal Range, he turned his attention to collecting previous records of temperature, etc. He found that meteorological observations had been made at the Apartments of the Royal Society, Somerset House, from 1774 to 1781, and from 1787 to 1843. Mr. Symons has stated that "the thermometers were at a window on the Strand front, and were on a board nearly at a right angle to the window, and guarded, more or less, from morning and evening sun by other projecting boards, one on the east and the other on the west." Mr. Glaisher extracted all the thermometrical observations and applied his corrections for the various hours of readings, and by this method obtained a very fair approximation to the mean temperature. He communicated the results to the Royal Society in a paper in 1849. He next proceeded to connect this series of results with those deduced from the observations at the Royal Observatory, Greenwich, and he reduced the two series of observations to one and the same series. He also procured a few years' earlier observations, and filled up the gap between 1781 and 1786, so as to make a continuous record from 1771 to 1849. These results he communicated to the Royal Society in a second paper in 1850.

Although there may be some doubt attaching to some of the early values, this is the most complete and valuable record of mean temperature for the neighbourhood of London which we possess.

The DAILY NEWS *Weather Reports.*

I have given a full account of these reports in my paper, "The Earliest Telegraphic Daily Meteorological Reports and Weather Maps," which appeared in the *Quarterly Journal*, vol. **29**, p. 123. It will therefore be necessary to say but little on the subject. The *Daily News* published a telegraphic daily report of the "State of the Wind and Weather" for the two months August 30 to October 30, 1848. On the discontinuance of these reports, the Astronomer-Royal, Sir George (then Mr.) Airy, wrote to the editor expressing the hope that the reports would be continued, as they were likely to lead to results of considerable value. Some correspondence took place on the subject, after which the *Daily News* decided to commence operations on a more extensive scale. They secured the co-operation of most of the great railway companies in order that the station-masters at many places might furnish the observations; and then Mr. Glaisher was requested to visit all the stations to examine the apparatus of wind-vanes, to furnish suggestions respecting the management, and to assist in fixing the bearing points. This inspection was begun in April 1849, and lasted several months. The first table of these new synchronous meteorological observations was published in the *Daily News* on June 14, 1849, and showed the state of the weather on the previous morning. The Table was as follows:—

METEOROLOGICAL TABLE,

Shewing the State of the Weather at each of the following places at Nine o'clock yesterday morning.

Name of Place.	Course of Wind.	Strength of Wind.	State of Weather.
BASINGSTOKE	W.	Gentle Breeze	Partially Cloudy
BRIDGEWATER	N.W.	Gentle Breeze	Cloudy
BRIGHTON	N.	Gentle Breeze	Partially Cloudy
BRISTOL	N.W.	Gentle Breeze	Nearly Cloudless
EXETER	N.W.	Gentle Breeze	Partially Cloudy
GLOUCESTER	N.E.	Gentle Breeze	Partially Cloudy
GREENWICH	N.E.	Gentle Breeze	Partially Cloudy
OXFORD	N.W.	Calm	Cloudless
PLYMOUTH	S.W.	Gentle Breeze	Partially Cloudy
POOLE	N.	Gentle Breeze	Partially Cloudy
READING	N.W.	Gentle Breeze	Partially Cloudy
SOUTHAMPTON	N.E.	Calm	Partially Cloudy
SWINDON	N.	Gentle Breeze	Partially Cloudy

As explained elsewhere, the very extensive arrangements necessary for making this table complete have not yet been concluded. In a short time we shall present daily returns in addition to those above given, from Berwick, Birmingham, Blackburne, Cambridge, Carlisle, Colchester, Conway, Crewe, Darlington, Dundee, Edinburgh, Folkestone, Galway, Halifax, Hartlepool, Hastings, Holyhead, Kingston, Lanark, Lancaster, Leeds, Leighton, Limerick, Liverpool, Manchester, Moffat, Newcastle, Peterborough, Portsmouth, Rochdale, Rugby, Shap, Sheffield, Sunderland, Tamworth, Tunbridge, Whitby, and York.

British Meteorological Society.

No doubt Mr. Glaisher had seen, in the course of his organisation of the staff of observers for the Registrar-General, that the science of Meteorology would be greatly advanced if the observers, and others interested in the subject, were federated into a Society; and so, with the co-operation of Dr. J. Lee, Mr. S. C. Whitbread, and a few others, he founded the British Meteorological Society on April 3, 1850. The Meeting was held at Dr. Lee's residence, Hartwell House, Bucks (Plate I.)

It may be desirable to quote the following extract from the Address of the British Meteorological Society:—

"The science of Meteorology has remained up to the present time without that assistance which is given to many other branches of physical inquiry by associated bodies. Its successful study, however, requires the combined efforts of numerous observers, steadily following a well-concerted plan, employing the same class of instruments, and reducing their results in the same form. In order to secure these advantages, it has long been a matter of consideration whether the benefit of association, already found to be so important in advancing other physical sciences, may not be made available to encourage and support that of Meteorology.

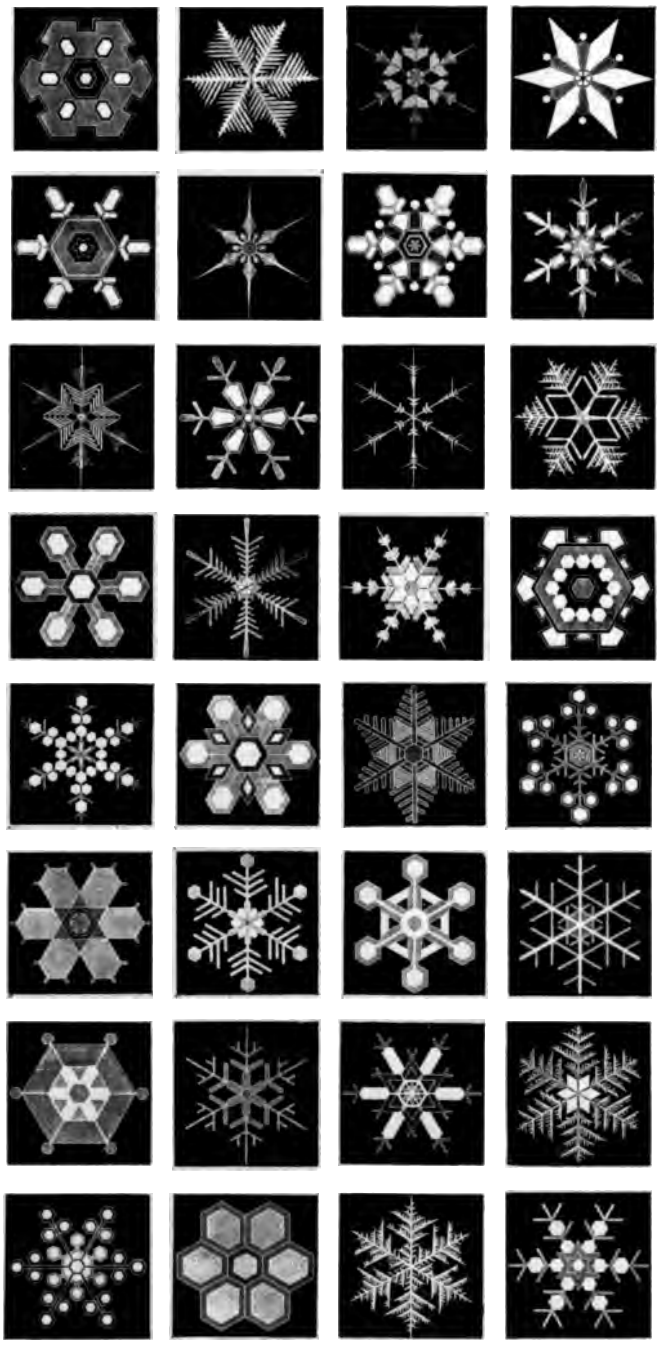
"With this intention, a Society has been formed, to be called the 'British Meteorological Society.' This proposal has been most cordially entertained: above one hundred gentlemen have become members; and the Council which has been formed, in making this announcement public, hope that others interested in the advancement of this science will either join it as members, or extend its sphere of usefulness by contributing truthful observations.

"The increased attention which has been paid within the last few years to the construction of instruments and the determination of their



HARTWELL HOUSE, BUCKS, WHERE THE BRITISH METEOROLOGICAL SOCIETY WAS FOUNDED, APRIL 3, 1850.

(Reproduced from *Ædes Hartwellianæ*, by Admiral W. H. Smyth, London, 1851.)



SNOW CRYSTALS, OBSERVED BY JAMES GLAISHER, F.R.S.

Quart. Journ. Roy. Met. Soc. vol. xxx. pl. 2.

index errors, to the examination of observations and their uniform reduction, combination, and publication of the results, has induced, in widely distant parts of the country, a number of trustworthy observers to become practical Meteorologists, and diligently to observe those atmospherical phenomena which have been hitherto considered adequate for determining average values, the character of a climate, and the influence it exerts on mortality and disease."

Mr. Glaisher held the office of Secretary from 1850 to 1872, except for the two years 1867-68, when he was President. He took a great interest in the welfare of the Society, and it may be confidently stated that in the early years he *was* the Society.

Great Exhibition, 1851.

Mr. Glaisher was appointed a Juror for Class X. in the Great Exhibition of 1851. This class was devoted to Philosophical Instruments. In his capacity of Reporter he drew up a very elaborate and comprehensive Report on the exhibits in this section. A large number of barometers, thermometers, and other instruments intended for meteorological observations were exhibited; but the greater part were of a very ordinary kind, and unsuited to the work intended. It is stated that "Mr. Simms and Messrs. Negretti and Zambra were the only exhibitors in the British portion who have sent thermometers with their stems graduated, the only safe instruments for delicate experiments."

On February 4, 1852, at the Society of Arts, Mr. Glaisher gave one of the Lectures on the Exhibition instituted at the suggestion of His Royal Highness Prince Albert. The following extract is interesting as showing the state of meteorological observers and instruments at that time:—

"The collection of Meteorological Instruments in the Exhibition would lead us to the conclusion that the conditions of good instruments are better understood and fulfilled by makers abroad than at home. That this will speedily cease to be the case, I feel assured. The opportunity offered to the members of the Jury of expressing their disapprobation to the makers, added to the increasing demand for good instruments, and to the fact of the public becoming acquainted with the deficiencies of those usually furnished to them, will enforce a demand for instruments worthy the investment of their time and money; and when we consider how worse than useless is the labour of the meteorologist when based upon bad or insufficient instruments, and how by these means he becomes instrumental to the propagation of error, this circumstance alone demands increased care in the selection of those used. That the want of good instruments is experienced I can myself testify. For years I have pursued the subject of meteorology, and have long been convinced that a widely spread and universal system of simultaneous observation, uniformly reduced, must be the groundwork of its establishment as a science. For the sake of this establishment, I, by my individual and unassisted exertions, six years ago reduced my system to practice; and introducing it first among the meteorological observers, contributors to the Reports of the Registrar-General, in a short time perceived with satisfaction some of the good results upon a limited scale. The observations thus made and reduced were published quarterly in the Reports of the Registrar-General at that time. Since then I have been gradually, and with success, increasing the number of my observers, and have now established

upwards of fifty meteorological stations in different parts of the country, all of which contribute observations made and reduced upon my own system. The publication of these Quarterly Reports, giving the combined results, has mainly laid the foundation of the present system of meteorology. The ready co-operation I have met with from gentlemen engaged in its pursuit has convinced me that they were only too glad to have direction given to their work, whilst the ready engagement of other gentlemen in this pursuit is equally convincing that they had waited only for a clear perception of its utility. I now come to that which had nearly caused the subversion of my scheme—the difficulty of obtaining good instruments at a fair and moderate price. To remedy this evil to any great extent, was not in my power. Of the means possessed by me, I, however, availed myself, and have caused the construction of many barometers and thermometers superior to those previously in use. That I have been enabled to do this is owing to the co-operation of Mr. Barrow, who, anxious for the furtherance of truth, complied with my request, and devoted his time and talents to the advancement of my views. All the barometers, and the greater part of the thermometers, scattered among my corps of observers have been made, under my direction, by him, and constitute, with few exceptions, the most efficient instruments at their command.

"The establishment of my system has been followed, first, by the Ordnance furnishing themselves with twenty sets of instruments, to plant twenty meteorological observatories at their stations, and next by twenty sets which are now being prepared by Col. Sykes for as many observatories in India.

"The Exhibition may be a means of contributing to the improvement of meteorological instruments generally.

"The public will have been informed of those localities where the best instruments may be procured, and where, without doubt, they will enforce the greatest demand. If to the good results of the Exhibition, as applied to a meteorological science, I may add my own personal influence, I earnestly exhort all gentlemen, either designing to commence or already engaged in meteorological research, to use instruments such only as I have described as efficient, or abandon the pursuit entirely."

[*Discussion of Greenwich Observations.*

As the observations at the Royal Observatory, Greenwich, accumulated, Mr. Glaisher discussed them from time to time, and communicated the results in numerous papers which he read before this Society. Among the principal subjects which he dealt with may be mentioned: (1) Mean Temperature on every day of the year, 1814-73 (3 papers); (2) Mean Pressure of the Atmosphere on every day of the year, 1841-58; (3) Fall of Rain on every day of the year, 1815-69; (4) Direction of the Wind, 1841-70 (2 papers).

In 1865 he dealt with the "Secular Increase of Mean Temperature," and came to the following conclusions:—(1) that our climate has altered in the last 100 years; (2) that the temperature of the year is 2° warmer now than it was then; (3) that the month of January is 3° warmer; and (4) that the winter months are all much warmer, and every month of the year seems to be somewhat warmer than before. It is hardly necessary to point out that with instruments thoroughly comparable in every respect, and with observations extending to the present time, somewhat different conclusions might have been arrived at.

Meteorology and Cholera.

In 1854 Mr. Glaisher was requested by the General Board of Health to prepare a report upon the meteorology of London in relation to the epidemic of cholera, 1853-54, which he submitted on March 8, 1855. He prepared elaborate tables of Meteorological Observations made at twenty-five stations in and around London, and also inquired into the atmospheric conditions of the years 1832 and 1849, when there were former epidemics of cholera. His conclusions were to the following effect:—"The three epidemics were attended with a particular state of atmosphere, characterised by a prevalent mist, thin in high places, dense in low. During the height of the epidemic, in all cases, the reading of the barometer was remarkably high, and the atmosphere thick. In 1849 and 1854 the temperature was above its average, and a total absence of rain, and a stillness of air amounting almost to calm, accompanied the progress of the disease on each occasion. In places near the river the night temperatures were high, with small diurnal range, a dense, torpid mist, and air charged with the many impurities arising from the exhalations of the river and adjoining marshes, a deficiency of electricity, and, as shown in 1854, a total absence of ozone, most probably destroyed by the decomposition of the organic matter with which the air in these situations is strongly charged.

"In 1849 and 1854 the first decline of the disease was marked by a decrease in the readings of the barometer, and in the temperature of air and water; the air, which previously for a long time had continued calm, was succeeded by a strong S.W. wind, which soon dissipated the former stagnant and poisonous atmosphere. In both periods, at the end of September the temperature of the Thames fell below 60°, but in 1854 the barometer again increased, the air became again stagnant, and the decline of the disease was considerably checked. It continued, however, gradually to subside, although the months of November and December were nearly as misty as that of September. By the close of the year diarrhœa and cholera had subsided, but a high rate of mortality still continued.

"The coexistence of cholera with coincident meteorological phenomena is, to say the least of it, remarkable; so is the stagnant atmosphere prevalent during the time of cholera in each of the three periods, and which would seem to be a necessary condition to the activity of the disease.

"The inimical nature of the influence it exercises upon the public health, I regard as intimately connected with the state of the water and the marshes, which in the preceding pages are shown to be large evaporating surfaces for every description of poisonous exhalations. Impure water and impure air are inseparable, for the impurities of the former will be concentrated into the surrounding atmosphere, and there remain, unless rapidly dispersed under favourable atmospheric conditions.

"The agency of the river in fostering diseases is confirmed by the history of cholera just traced, and which we find to have been most fatal in low situations, and in London in those places on the south side of the Thames which afford an undisturbed lodgment for the reception of the air charged with the poisonous elements from evaporation and exhalation. The effect of a gentle wind is to float this atmosphere to enclosed spots, where its malignity becomes concentrated."

During the epidemic of cholera in 1866, Mr. Glaisher made special observations in order to note the appearance of the "blue mist," and he also induced a number of his observers to take measurements of the depth of water in wells in their neighbourhood. The results of these observations, however, were not published; they are only in manuscript.

Snow Crystals.

In the early part of 1855—the Crimean winter—there was a considerable fall of snow, which lay on the ground from the middle of January till the end of February. Much of it was of that peculiar character which former writers designated Polar Snow, it having been chiefly composed of crystalline particles, which they supposed to be confined, with rare exceptions, to the Arctic regions. This supposition Mr. Glaisher found was not supported by the prevalence of innumerable crystals during that winter, which exhibited a degree of crystalline formation equal to any that had been recorded in colder latitudes. He carefully examined the snow, and made a number of rough sketches of various forms, which Mrs. Glaisher redrew under his supervision, and illustrations of 151 varieties were printed in the *Report of the Council of the British Meteorological Society* for 1855. The primary figure or base of each crystal he determined to be a star of six radii, or a hexagon of laminæ, and the compound varieties to include combinations of spiculæ, prisms, cubes, and rhomboids, aggregated upon and around the central figure, according to the degree of its complexity.

I understand from Dr. Glaisher that the accompanying illustrations of snow crystals, prepared by Mr. Glaisher, have not hitherto been published (Plate II.)

Northumberland Coast Barometers.

In 1860, through the liberality of the Duke of Northumberland, and by the exertions of Mr. T. Sopwith (the President of this Society) and Mr. Glaisher, a number of barometers and other instruments were placed at numerous stations along the coast of Northumberland, with the view of rendering service in preventing calamities at sea. This scheme was under the approval of the Council of this Society. The barometers were purposely planned by Mr. Glaisher in conformity with views expressed by the Duke of Northumberland, and more especially was attention bestowed on their being *plain, strong, easily read, not readily liable to injury by movement*, and as *moderate in price* as was consistent with good workmanship.

They bore an inscription as follows:—

Northumberland Coast Stations.
Barometer No. 1.

Established by His Grace the Duke of Northumberland
and
The British Meteorological Society.

Barometer reads correctly with Greenwich Standard.
September 1860. JAS. GLAISHER, F.R.S.

Fourteen barometers were put up by Mr. Glaisher in September 1860, and instructions given by him to the various observers at the several stations.

The Royal National Lifeboat Institution also took up the question of supplying barometers to their lifeboat stations, and adopted the above pattern of instrument, which is a familiar object at nearly all seaside places. At the request of the Institution, Mr. Glaisher prepared "Directions for fixing Coast Barometers, and for keeping a Barometer Chart." He also contributed several articles to the *Lifeboat Journal*.

Meteorology of India.

At the request of the Commission of Inquiry into the Sanitary State of the Army in India, Mr. Glaisher in 1863 prepared a "Report on the Meteorology of India" in relation to the health of the troops there stationed. In this he included the results of all the meteorological observations made in India which he could procure. These, however, did not appear to be very satisfactory, for he concludes his report as follows:—"I cannot help expressing the hope that future meteorological observations in India may be carried out under some general system on a uniform plan, both with respect to instruments, their position and general instructions."

Parliamentary Committees.

Mr. Glaisher frequently gave evidence before Parliamentary Committees on the subject of rainfall and evaporation in connection with Bills dealing with Water Supply. The following is an interesting example:—

LONDON (WATFORD) SPRING WATER COMPANY'S BILL.

June 16, 1852.

JAMES GLAISHER, Esq., F.R.S., cross-examined by Mr. Serjeant BELLASIS.—What are the nature of the rain-gauges of which you spoke yesterday; are they open gauges?—They are open gauges; it is a simple cylinder gauge with an inverted funnel, the lower part of the funnel being turned up so that the largest portion of water that falls, falls on the bent tube, and prevents evaporation going forward.

That gauge shows you the actual quantity falling in any given period?—That which we consider to represent it more truly than any other.

As nearly as may be, it shows you the actual rainfall, whether it falls in floods or whether it falls gradually?—Yes.

Has the average rainfall in any district any sort of relation to the quantity of water penetrating to the substratum?—That is a question which I am not come here to answer; I may observe that the quantity of water which will pass to the substratum must depend upon the nature of the substratum. If it be a hard substance, it will flow over the surface; if it be clay, it will be retained upon the surface.

Assuming in both cases the same surface, namely, a surface liable to have water percolate through it, has the annual quantity of water falling on the surface any relation to the quantity which will actually percolate through?—It must do so; but I am here principally to speak to the quantity which falls.

I have had experiments made on that subject, and not upon the quantity which has percolated through the earth.

When we get a gentleman of your scientific attainments here, it is very desirable to obtain from him any information he can give. I understand you to say that you come here to speak only of the rainfall?—Yes.

And you know nothing of the quantity which percolates through the surface?—I have not made any experiments upon the subject.

You have taken some pains in respect to these rain-gauges; are you aware that there are gauges which show, or profess to show, the quantity which percolates actually into the stratum of water below?—Dr. Dalton mentions such gauges, and such gauges go by the name of Dalton's gauges. Mr. Dickinson, I think, has published some such observations in the *Engineer's Journal*, which I have seen. Mr. Charnock, at Leeds, has also made similar observations, of which he sent me a series some few years ago, which I have not fully discussed; beyond those I do not know of any observations of the kind.

You appear to be perfectly aware that there are rain-gauges which show not only the quantity of water falling, but the quantity of water which percolates?—A few such I know there are, or which profess to be so.

Was Dr. Dalton an ordinary person, or a person of extraordinary talent?—He was a person of extraordinary talent.

Particularly upon matters of this kind?—Upon matters of this kind.

Does this (*a diagram being shown to the witness*) in some degree represent Dr. Dalton's rain-gauge, so far as you understand it?—The form may be so, but that, I think, as far as I have seen, represents Mr. Dickinson's gauge, which I have never inspected, but I believe it to be of wood, a material which I do not think is the fittest for obtaining accurate observations; that is one reason why I have paid so little attention to it. Mr. Dickinson has never forwarded to me any of his results, and I have never been in a situation to correspond with him; I have considered that gauge as defective.

Will you abstract your mind from any particular gauge and tell me whether this generally represents the form of Dr. Dalton's gauge?—I believe it to do so.

Do those two perpendicular lines represent a vessel of some material, whether of tin, iron, or wood, or any other material?—Charnock's, at Leeds, was made of metal, and was infinitely better than that of Mr. Dickinson's, which was made of wood.

Will you dismiss from your mind any particular gauge of any particular individual, and confine yourself to the scientific structure of Dr. Dalton's gauge: does this represent that gauge, namely a vessel of some material filled with earth and covered with vegetation at the top, and having a pipe at the bottom from which any water which percolates through it will flow?—It may be so, but I consider its form and construction is objectionable: there is the general principle of Dr. Dalton's gauge there no doubt.

Will you be good enough to dismiss any allusion to Mr. Dickinson or his particular gauge, and tell me whether Dr. Dalton's gauge did not consist of a certain number of feet in depth, and of a certain diameter, made of some metal or other material?—I cannot say; I do not know that it is limited to any particular size or diameter at all.

What do you understand Dr. Dalton's gauge to have been?—Dr. Dalton's gauge was intended to ascertain the amount of water percolating through a certain depth of earth, to measure that quantity after it had so percolated.

Assuming the perpendicular lines on this diagram, which I hold up to you, to represent a section of a vessel three feet deep, assuming that to be filled with earth of the same nature as the earth around it, and to be covered with vegetation

as it is represented to be here, would not that gauge exhibit, by the pipe at the bottom, the quantity of water which percolated through the three feet of earth?—If we assume that none would percolate through the sides of the material, if we assume it is perfect in its form and in its construction, which no gauge can be, it would do so, but there is one objection to the measuring part there.

You say no gauge can be made perfect; cannot any gauge be made water-tight?—Yes, it can be.

What is your objection to Dr. Dalton's gauge?—The material of a gauge should be such as that no water can percolate through it.

You say there can be such a material?—There can.

Assuming it to be so made, will not a vessel which is constructed of a material impervious to water, and of the size I describe, three feet in depth, exhibit, by the pipe running out of the bottom, the quantity of water percolating through that three feet of soil?—It will.

Is not there well known among scientific men a machine invented by a person of great scientific reputation, for measuring the quantity of water which actually percolates at various times of the year through that soil?—Such a gauge was suggested by Dr. Dalton, but has not been generally adopted, and I have not asked for such a gauge to be used, because the quantity will vary with every different stratum in which it is placed. It will apply to its own particular locality, but perhaps only to a very short distance around it; the design of the experiments I have instituted has been, not only to show the results applying to the general locality, but to afford general information. I have endeavoured so to plant my gauges that I shall know the amount which actually does fall.

Your present line of gauges are placed in various localities?—Yes.

And they exhibit the rainfall in each of those localities?—Yes.

If you had in each of those localities Dr. Dalton's gauge, properly constructed, would not it show you the quantity of water percolating in those localities?—Yes, properly measured and properly constructed, it would do so.

You never thought of doing so?—I do not consider the state of meteorology to be such as to attach value to the matter. It is a matter on which I have had some conversations five or six years since.

I understand your answer to be that the state of meteorology in this country is not such as to make it desirable, in your judgment, to use such instruments?—I am very anxious to get information of all kinds upon the subject, but they might get one or two results, but not more, and those would give them very little information.

Are you aware of the nature of this inquiry sufficiently to know that the great point of the inquiry is, how much of the fall of water gets through into the stratum below?—That may be the nature of the inquiry, but it is not the nature of the information which I am come here to give.

Are you aware of the fact, that the main point here is to consider how much of the water which falls gets into the stratum below?—Not absolutely.

Were you the gentleman who informed the Counsel on the other side that the water which is now pumped up at Watford fell probably in the reign of Charles the First?—No.

Do you believe it?—No, I certainly do not believe in it.

Do you know anything about the nature of the wells in London?—Not much.

Your inquiries have never been turned in the direction of knowing the level of the water in the London wells?—They are variable. I was with Mr. Whitbread some short time since; his father had sunk wells, and others had sunk them in the neighbourhood, and he was obliged to go deeper and deeper

still. Beyond the temperature of the water in those wells I am not acquainted with them.

Are you aware that the level of the London wells is about 60 feet below what it was a very few years ago?—I am not aware of the depth; I am aware that it is at a lower level than it was.

The rain-gauge referred to in the first question is that known as "Glaisher's." It had a small curved pipe beneath the funnel, in which a little water is retained, in order to prevent any evaporation of the water in the can below. The curved pipe, however, is at times liable to become choked up with leaves and dust.

Balloon Ascents, 1862-66.

Mr. Glaisher was perhaps best known to the public for the famous balloon ascents which he made for scientific purposes. It will therefore be desirable to describe these somewhat fully.

In the year 1852 Mr. Welsh of the Kew Observatory made four ascents for scientific purposes in the great *Nassau* balloon, with Mr. Green as aeronaut. The heights reached were 19,500, 19,100, 12,640, and 22,930 feet respectively. Owing to illness, Mr. Welsh was not able to make any more ascents.

At the meeting of the British Association at Leeds in 1858, Col. Sykes urged the desirability of having further observations made in balloons on the decrease of temperature with altitude, and a Committee was appointed to consider how this could be carried out, but little or nothing was done. In 1861 the Committee was re-appointed, and then consisted of Col. Sykes (chairman), Mr. Airy, Sir D. Brewster, Mr. Fairbairn, Admiral FitzRoy, Mr. Gassiot, Mr. Glaisher, Sir J. Herschel, Dr. Lee, Dr. Lloyd, Dr. Miller, Dr. Robinson, and Dr. Tyndall. Arrangements were made with Mr. Green for the use of his balloon, and two young observers were instructed by Mr. Glaisher in the method of taking the observations. Difficulties, however, arose, which frustrated the expectations of the Committee. The balloon was rent by the wind while it was being filled for the first ascent, and subsequently it was found to be leaky and incapable of rising to any great altitude. In addition to this, the observers proved to be incompetent.

The Committee then approached Mr. H. Coxwell, the aeronaut, on the subject. After a full discussion of the objects proposed, it became evident that if high ascents were to be made it would be necessary to construct a new balloon of greater capacity than previously made. The Committee were in despair at this, as the cost was beyond their means. Mr. Coxwell, however, generously undertook, at his own cost, to construct the required balloon, provided the Committee would use it. This they readily agreed to, and Mr. Glaisher then said that he would make the observations himself. And so it came about that the *Mammoth* balloon was made, which was 80 feet high and had a diameter of 55 feet, and when fully inflated was capable of containing over 93,000 cubic feet of gas.

The primary objects of the experiments as set forth by the Committee were the determination of the temperature of the air, and its hygrometrical states, at different elevations, as high as possible. The

secondary objects were: (1) to determine the temperature of the dew-point by Daniell's and Regnault's hygrometers, as well as by the dry- and wet-bulb thermometers, and to compare the results; (2) to compare the readings of an aneroid barometer with those of a mercurial barometer up to the height of 5 miles; (3) to determine the electrical state of the air; (4) the oxygenic condition of the air; and (5) the time of vibration of a magnet; (6) to collect air at different elevations; (7) to note the height and kind of clouds, their density and thickness; (8) to determine the rate and direction of different currents in the atmosphere; and (9) to make observations on sound.

This was a large and comprehensive programme, and Mr. Glaisher took steps forthwith to endeavour to carry it out. A special and elaborate set of high-class instruments were procured from the best



FIG. 1.—Balloon Car with Observers and Instruments.

makers, which were all carefully tested, and then Mr. Glaisher set to work to practise himself in manipulating and reading the instruments so that he might do so carefully and quickly when up in the balloon. He had a board or table made, the extremities of which rested on the sides of the car, and on this he arranged the instruments. The instruments were the following:—Mercurial and Aneroid Barometers; Dry- and Wet-bulb Thermometers; Daniell's Dew-point Hygrometer; Regnault's Condensing Hygrometer; Maximum and Minimum Thermometers; a Magnet for horizontal vibration; hermetically sealed glass tubes exhausted of air; and an Electrometer. A camera was also taken up in one or two ascents.

This was the equipment for high ascents. Mr. Glaisher sat at one end of the car facing the instruments, Mr. Coxwell being at the other end (Fig. 1). The instruments were fastened to the table with strings, which could be cut immediately, or they merely rested on stands which were screwed to the table. In descending, when approaching the earth, Mr. Glaisher

rapidly removed the instruments and placed them in a basket between a number of soft cushions so that they might not be broken by the shock on coming in contact with the earth.

The cost of each high ascent which was made specially for the British Association Committee, when Mr. Glaisher and Mr. Coxwell were the only occupants of the car, was about £50. As the grant of the

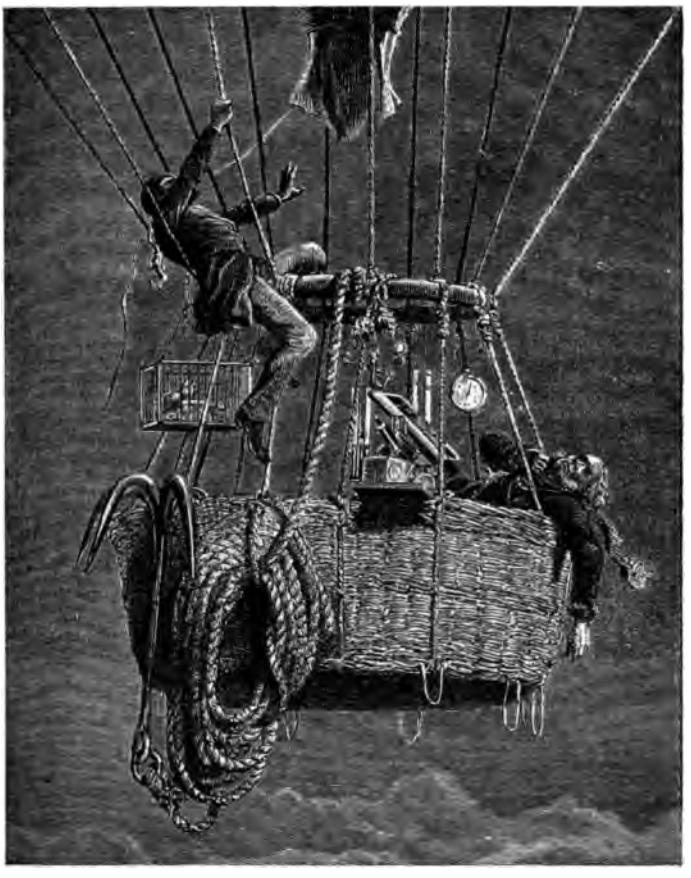


Fig. 2.—Glaisher and Coxwell 7 miles above the Earth, September 5, 1862.

British Association would only permit a few high ascents being made, Mr. Glaisher availed himself of the opportunity of accompanying Mr. Coxwell as often as possible in his balloon ascents from the Crystal Palace and elsewhere which were made for exhibition purposes. On these occasions he paid his fee as an ordinary passenger in the car, but had a small board fixed outside the car on which he placed the thermometers and hygrometers.

The accompanying table gives a list of the 28 balloon ascents made by Mr. Glaisher: 8 of which were in 1862, 8 in 1863, 8 in 1864, 3 in

GLAISHER'S BALLOON ASCENTS, 1862-1866.

No. of Ascent.	Date.	Ascent.		Descent.		Greatest Altitude.	Temperature.		
		Time.	Place.	Time.	Place.		Start.	Lowest.	Finish.
	1862					ft.	°	°	°
1	July 17 .	9.43 a.m.	Wolverhampton . .	11.50 a.m.	Langham . . .	26,177	59·0	16·0	...
2	,, 30 .	4.40 p.m.	Crystal Palace . .	6.30 p.m.	Singlewell . . .	6,937	68·0	41·0	68·0
3	August 18 .	1.2 p.m.	Wolverhampton . .	4.5 p.m.	Solihull, 7 miles from B'm	23,377	67·8	19·0	67·0
4	,, 20 .	6.26 p.m.	Crystal Palace . .	10 p.m.	Mill Hill . . .	5,900	66·2	43·0	...
5	,, 21 .	4.30 a.m.	Mill Hill . . .	7.10 a.m.	Biggleswade . . .	14,355	60·8	19·3	61·8
6	September 1 .	4.40 p.m.	Crystal Palace . .	6.15 p.m.	Woking	4,190	65·0	46·1	...
7	,, 5 .	1.3 p.m.	Wolverhampton . .	3.6 p.m.	Cold Weston . . .	37,300	59·5	5·0	57·2
8	,, 8 .	4.47 p.m.	Crystal Palace . .	6.10 p.m.	Mucking Flats . .	5,428	67·2	49·3	...
	1863								
9	March 31 .	4.16 p.m.	Crystal Palace . .	6.30 p.m.	Barking Side . . .	22,884	49·2	1·0	42·0
10	April 18 .	1.16 p.m.	Crystal Palace . .	2.46 p.m.	Newhaven . . .	24,163	61·5	11·5	57·0
11	June 26 .	1.3 p.m.	Wolverton . . .	2.28 p.m.	Little Port . . .	23,200	66·0	17·0	66·5
12	July 11 . .	4.55 p.m.	Crystal Palace . .	8.50 p.m.	Goodwood Park . .	6,623	73·5	51·0	68·5
13	,, 21 . .	4.52 p.m.	Crystal Palace . .	5.45 p.m.	Waltham Abbey . .	3,298	61·3	52·2	61·5
14	August 31 .	6.12 p.m.	Newcastle-on-Tyne .	7.5 p.m.	Pittington . . .	8,033	64·0	33·5	53·5
15	September 29	7.43 a.m.	Wolverhampton . .	10.30 a.m.	Temple Bruer . .	16,590	48·0	0·0	53·0
16	October 9 .	4.29 p.m.	Crystal Palace . .	6.30 p.m.	Pirton Grange . .	7,310	54·5	26·5	...
	1864								
17	January 12 .	2.7 p.m.	Woolwich . . .	4.19 p.m.	Near Brandon . .	11,897	42·0	11·0	41·8
18	April 6 . .	4.8 p.m.	Woolwich . . .	5.17 p.m.	Near Sevenoaks . .	11,075	46·0	33·0	47·0
19	June 13 .	7.0 p.m.	Crystal Palace . .	8.15 p.m.	East Hornden . .	3,543	61·8	46·0	54·0
20	,, 20 .	6.17 p.m.	Derby	7.16 p.m.	Near Newark . .	4,280	65·0	49·2	64·0
21	,, 27 .	6.33 p.m.	Crystal Palace . .	9.21 p.m.	Romney Marsh . .	4,898	63·0	40·2	46·5
22	August 29 .	4.6 p.m.	Crystal Palace . .	5.30 p.m.	Wybridge, Essex . .	14,581	72·5	28·5	69·0
23	December 1 .	2.37 p.m.	Woolwich . . .	4.35 p.m.	Near Rochester . .	5,431	48·0	29·1	45·2
24	,, 30 .	2.13 p.m.	Woolwich . . .	3.10 p.m.	Stanford le Hope . .	3,735	42·5	27·2	38·2
	1865								
25	February 27 .	1.58 p.m.	Woolwich . . .	4.1 p.m.	South Hanningfield .	4,865	52·1	{34·0 / 32·5}	44·5
26	October 2 .	6.20 p.m.	Woolwich . . .	8.20 p.m.	Highmoor (Ox.) . .	1,949	56·0	...	56·0
27	December 2 .	5.15 p.m.	Woolwich . . .	7 p.m.	Ridgemouth . . .	4,628	38·3	27·2	39·3
	1866								
28	May 29 . .	6.14 p.m.	Windsor . . .	9.25 p.m.	Near Pulborough . .	6,325	58·0	{29·5 / 33·5}	50·2

1865, and 1 in 1866. The 4 from Wolverhampton and the 7 from Woolwich were undertaken wholly on behalf of the British Association Committee.

A full account of the various ascents, with the observations *in extenso*, will be found in the *Reports of the British Association* for the years 1862, 1863, 1864, 1865, and 1866.

The highest ascent was that from Wolverhampton on September 5, 1862, when the height of about 7 miles from the earth was reached. Mr. Glaisher was rendered insensible, while Mr. Coxwell's hands were frozen and he was only able to open the valve by tugging away at the rope with his teeth (Fig. 2). [Figs. 1 and 2 are reproduced from *Travels in the Air*, by permission of Messrs. Macmillan and Co.]

The following verses on this remarkable ascent, from *Punch*, will be read with interest:—

COXWELL AND GLAISHER.

A Song by a Schoolboy.

'Tis of the youthful Icarus
The ancient poet sings,
For whom his daddy, Dædalus,
Made certain waxen wings;
But, flying up too near the Sun,
His wings of wax did melt,
And then he came right down like fun,
As hard as he could pelt.

A great deal faster than he rose
Apace descended he,
Until he ended all his woes
In the Ægean Sea.
Now what a lie is that account!
About the hour of noon
Glaisher and Coxwell both did mount
Six miles in a balloon.

No mortal man could soar so high,
Because, at that great height,
A pigeon they let out to fly,
Could not effect its flight.
Half stifled for the want of breath
Was Coxwell, Glaisher too;
Glaisher was nearly froze to death,
And Coxwell's hands turned blue.

Aloft 'tis cold instead of hot;
Wax wings would freeze, not run,
By which a chap as near had got,
As could be, to the Sun.
As snow upon a mountain's top
Might show to every fool,
So that slow fable you must drop
That we are taught at school.

But Glaisher's pluck, and Coxwell's too,
Is something to admire;
As high as eagle ever flew
Those fellows went, and higher.
One kept on reading at his glass,
Whilst he could see or stand;
The other's teeth let out the gas,
When cold had numbed his hand.

'Tis true that these two men did go
Six miles towards the sky;
But as for Icarus, we know
That story's all my eye.
Then what's the use to read about
Old heroes' fabled acts,
When now they're beaten, out and out,
By wonders that are facts?

The following are some of the results derived from the experiments in the balloon ascents:—

1. The rate of the decline of temperature with elevation near the earth was very different when the sky was clear from what was the case when it was cloudy; and the equality of temperature at sunset and increase with height after sunset were very remarkable facts which were not anticipated.

2. Even at the height of 5 miles cirrus clouds were seen high in the air, apparently as far above as they seem when viewed from the earth.

3. The results of the observations differed very much, and no doubt the atmospheric conditions depended not only on the time of day, but also on the season of the year, and were such that a vast number of ascents would be requisite to determine the true laws with anything approaching to certainty and completeness. It is also clear that England is a most unfit country for the pursuit of such investigations, as, from whatever place the balloon started, it was never safe to be more than an hour above the clouds for fear of reaching the sea.

4. It appeared from the observations that an aneroid barometer could be trusted to read as accurately as a mercurial barometer to the heights reached.

5. The time of vibration of a horizontal magnet was taken in very many of the ascents, and the results of ten different sets of observations proved undoubtedly that the time of vibration was longer than on the earth.

6. In almost all the ascents the balloon was under the influence of currents of air in different directions. The thickness of these currents was found to vary greatly. The direction of the wind on the earth was sometimes that of the whole mass of air up to 20,000 feet; whilst at other times the direction changed within 500 feet of the earth. Sometimes directly opposite currents were met with at different heights in the same ascent, and three or four streams of air were encountered moving in different directions. Ignoring the different currents of air which caused the balloon to change its direction, and at times to move in entirely opposite directions, and simply taking into account the places of ascent

and descent, the distances so measured were always very much greater than the horizontal movement of the air as measured by anemometers. For example, on January 12, 1864, the balloon left Woolwich at 2.7 p.m., and descended at Lakenheath, 70 miles distant from the place of ascent, at 4.19 p.m. At the Greenwich Observatory, by Robinson's anemometer, during this time the motion of the air was 6 miles only.

7. With regard to physiological observations, Mr. Glaisher found that the number of pulsations increased with elevation, as also the number of inspirations. The number of his pulsations was generally 76 per minute before starting, about 90 at 10,000 feet, 100 at 20,000 feet, and 110 at higher elevations. But a good deal depended on the temperament of the individual. This was also the case in respect to colour; at 10,000 feet the faces of some would be a glowing purple, whilst others would be scarcely affected. At 4 miles high Mr. Glaisher found the pulsations of his heart distinctly audible, and his breathing was very much affected, so that panting was produced by the very slightest exertion; at 29,000 feet he became insensible.

8. In reference to the propagation of sound, it was at all times found that sounds from the earth were more or less audible according to the amount of moisture in the air. When in clouds at 4 miles high, a railway train was heard; but when clouds were far below, no sound ever reached the ear at this elevation. The discharge of a gun was heard at 10,000 feet; the barking of a dog was heard at the height of 2 miles; while the shouting of a multitude of people was not audible at heights exceeding 4,000 feet.

It will be well to refer to Mr. Glaisher's coolness in the balloon ascents. This is what Mr. Coxwell said of him after their first ascent together, when in descending they came to the earth with a very considerable shock which broke nearly all the instruments:—"I have frequently expressed my astonishment and admiration of the personal bearing of Mr. Glaisher in the balloon-car, when he undertook, without previous schooling and initiation, to go up to an altitude of 5 miles. I had never myself been to that elevation, but had been, when alone, in Germany, as high as I could get with a balloon of 34,000 feet capacity; but this calm and self-possessed start on the part of Mr. Glaisher satisfied me as to his having the requisite qualifications for the duties upon which he had entered. I thought, too, that he even seemed to take a delight in the mode of travelling itself, and of the sight-seeing, scenery, and cloud-scapes which from time to time presented themselves, irrespective of the philosophical uses to which his notes and deductions were to be turned subsequently, when they were studied and gone into in his own systematic way. This, to me, was particularly gratifying, as I had read and heard of attempts by scientific men, years previously, who had trembled in the car and could not do justice to their own powers and abilities for want of nerve."

Captive Balloon Ascents, 1869.

Owing to the great ascending power of the balloon at starting from the earth, the first few hundred feet were passed through too quickly to enable Mr. Glaisher to make satisfactory observations on the temperature and humidity of the air at the lower elevations. He therefore, in

1869, readily took advantage of the offer of Mons. Giffard to permit him to make a number of observations in the car of the great Captive Balloon, then located at Ashburnham Park, Chelsea. This balloon was kept constantly inflated with 420,000 cubic feet of hydrogen gas, and it could ascend on a calm day to the height of 2,000 feet. Its rate of ascension could be regulated, and the balloon could be kept all but stationary at any point for any length of time.

The results of these observations supported those which were indicated by the free balloon ascents, viz.—that the decrease of temperature with increase of elevation has a diurnal range, and differs at different hours of the day, the changes being the greatest at mid-day and the early part of the afternoon, decreasing to about sunset, when, with a clear sky, there is little or no change of temperature through several hundred feet from the earth, whilst with a cloudy sky it decreases from the mid-day hours at a less rapid rate to about sunset, when the decrease is nearly uniform at the rate of 1° in 200 feet.

No observations were made after sunset.

In an ascent of the Captive Balloon on May 5, 1869, the wind was blowing very strongly. There were 29 persons in the car, including Mr. Glaisher. The wind whistled through the ropes, the balloon lay over, and the car oscillated violently. This is what Mons. W. de Fonvielle and Mons. G. Tissandier say: "Mr. Glaisher appeared to pay no attention to the wind, or to the oscillations of the balloon: his eyes remained fixed either upon his instruments or the dynamometer, which indicated a tension of three tons, therefore nothing to alarm us, since the cable could bear four times as much."

Observations in Palestine.

In his later years Mr. Glaisher was a member of the Committee of the Palestine Exploration Fund, and was for some time Chairman of the same.

MEAN RESULTS OF OBSERVATIONS MADE AT JERUSALEM, 2,500 FEET ABOVE SEA-LEVEL.

Month.	Barometer Reading.	Temperature.			Rainfall.	
		Mean Max.	Mean Min.	Mean.	Amount.	Days of Rain.
	ins.	°	°	°	ins.	
January	27·425	50·8	38·5	44·7	6·41	12
February	27·407	54·7	40·7	47·7	5·11	10
March	27·378	62·5	44·8	53·7	4·10	8
April	27·360	70·2	50·7	60·5	1·55	5
May	27·361	78·3	56·3	67·3	·26	2
June	27·342	84·5	61·6	73·0	...	0
July	27·266	87·2	64·6	75·9	...	0
August	27·287	88·1	64·5	76·2	...	0
September	27·379	85·0	61·5	73·3	·03	0
October	27·450	80·3	59·0	69·5	·37	2
November	27·465	65·5	49·5	57·5	2·37	7
December	27·451	56·4	43·1	49·8	5·67	10
Year	27·381	72·0	52·9	62·4	25·87	56

He worked up and discussed the meteorological observations which had been made at Jerusalem and other places in Palestine, and contributed several papers thereon, which were published in the *Quarterly Statement* of the Fund. His last paper, published in 1902, dealt with the barometer and thermometer results at Jerusalem for the 20 years 1882 to 1901, and with the rainfall for the 41 years 1861 to 1901. The mean results are shown in the accompanying Table (p. 21).

Conclusion.

I have endeavoured in the foregoing remarks to give an outline of some of the more important investigations and work upon which Mr. Glaisher was employed. We have seen in what a deplorable state Meteorology was in when the Magnetical and Meteorological Department of the Royal Observatory, Greenwich, was founded in 1840, and with what difficulties he had to contend.

By his untiring energy and perseverance he was able to induce the instrument-makers to manufacture more accurate and reliable instruments, and to organise a staff of observers over the country, whose records he discussed, and furnished the results to the Registrar-General with unfailing regularity for a period of over 55 years. He also carried out those remarkable balloon ascents which added much to our knowledge of the upper atmosphere.

This Society not only owes its existence to him, but was fortunate in being under the guidance of such a practical and capable man for many years.

Well might Prof. Cleveland Abbe call him the "Nestor of Meteorologists."

I am glad that this opportunity has been afforded me of paying a humble tribute to his memory.

APPENDIX.

Bibliographical List of the Published Meteorological Works and Papers of James Glaisher, F.R.S., 1847-1902.

The amount of the Radiation of Heat, at night, from the earth, and from various bodies placed on or near the surface of the earth. *Phil. Trans. Roy. Soc., London*, **1847** (119-216).

The Meteorology of England, and remarks on the Weather for each quarter. *Quarterly Return of Marriages, Births, and Deaths*, 1847-1902.

Hygrometrical Tables, containing the temperature of the dew-point, the elastic force and weight of vapour . . . corresponding to all readings of the dry and wet thermometers between 10° and 90° [&c.]. 8°. London, 1847. 2nd ed., 1856 ; 3rd ed., 1863 ; 4th ed., 1866 ; 5th ed., 1869 ; 6th ed., 1876 ; 7th ed., 1885 ; 8th ed., 1893 ; 9th ed., 1902.

The Aurora-Borealis of Oct. 24, 1847. *Phil. Mag., London*, **31**, 1847 (369-372).

Report on the Performance of an Aneroid Barometer. *Literary Gazette*, Jan. 29, 1848.

Remarks on the Weather during the quarters ending Dec. 31, 1847, and Mar. 31, 1848. *Phil. Mag., London*, **32**, 1848 (130-137 ; 506-518).

Corrections to be applied to the monthly means of meteorological observations taken at any hour, to convert them into mean monthly values. *Phil. Trans. Roy. Soc., London*, **1848** (125-140); *Ann. Mét., Paris*, **2**, 1850 (145-152).

Instructions for making and registering Meteorological Observations required to form the Quarterly Report furnished to the Registrar-General (5 pp.). *London*, 1848 or 1849.

The Meteorology of England in the Year 1847. *Phil. Mag., London*, 1849.

Reduction of the Thermometrical Observations made at the apartments of the Royal Society, from the years 1774 to 1781, and from the years 1787 to 1843. *Phil. Trans. Roy. Soc., London*, **1849** (307-318).

Description of the Aneroid Barometer. *Practical Mechanic's Journal, London*, 1849.

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Corrections to be applied to Meteorological Observations for Diurnal Range (prepared by the Council of the British Meteorological Society). 8° London, 1850.

Extraordinary fall of Rain in the neighbourhood of London. *Proc. Roy. Soc., London*, **6**, 1851 (39-41).

Philosophical Instruments and Processes, as represented in the Great Exhibition. *Lectures on the Results of the Great Exhibition of 1851, delivered before the Society of Arts, London*, 1852 (323-402).

Philosophical Instruments, and Processes depending upon their use. *Reports by the Juries, Exhibition, 1851. London*, 1852, 8° (243-323).

Determination of the Mean Temperature of every day in the year, as deduced from the observations taken at the Royal Observatory, Greenwich, in the years from 1814 to 1851. *Proc. Roy. Soc., London*, **6**, 1853 (281-282).

Meteorology of the quarter ending Dec. 31, 1853 and the beginning of the year 1854. *Rep. Brit. Met. Soc., London*, **1854** (9-17).

Fall of Rain in the years 1852 and 1853. *Rep. Brit. Met. Soc., London*, **1854** (23-27).

Snow Crystals in 1855. *J. Microsc. Sci., London*, **3**, 1855 (179-185).

Report on the Meteorology of London and its relation to the Epidemic of Cholera. [*Report to the General Board of Health.*] 8°. London, 1855.

Severe Weather at the beginning of the year 1855; and on Snow and Snow Crystals. *Rep. Brit. Met. Soc., London*, **1855** (12-30 and 36 pl.)

The late Severe Weather, as compared with that of 1814; and on the Crystals of Snow observed during its continuance. *Gard. Chron.*, **1855** (243).

Further observations on the similarity of forms observed between Snow Crystals and those of Camphor. *J. Microsc. Sci., London*, **4**, 1856 (203-205).

Table of the corrections for temperature to reduce observations to 32° Fahrenheit for Barometers with brass scales extending from the cistern to the top of the mercurial column. 8°. London, 1856. 2nd ed., 1880. 3rd ed., 1880.

Determination of the Mean Temperature of every day in the year, from all the thermometrical observations taken at the Royal Observatory, Greenwich, from the year 1814 to the end of 1856. *Rep. Brit. Met. Soc., London*, **1857** (56-62 and 12 folding tables).

Meteorology. [Paper in Hughes's *Reading Lesson Book*]. 12mo. London, 1857. Also published separately.

The Fall of Rain on October 22, 1857. *Rep. Brit. Met. Soc., London*, **1858** (10-27).

Periodical Phenomena in connection with the years 1855, 1856, and 1857. *Rep. Brit. Met. Soc., London*, **1858** (46-125); *Gard. Chron.*, **1858** (511-512).

Meteorological and Physical Effects of the Solar Eclipse of March 15, 1858. 8°. London, 1858. [*Appendix to Rep. Brit. Met. Soc.*, **1858**.]

Determination of the Mean Pressure of the Atmosphere on every day in the year as deduced from all the Barometrical observations taken at the Royal Observatory, Greenwich, from the year 1841 to 1858. *Rep. Brit. Met. Soc., London*, **1859-60** (11-31); *Gard. Chron.*, **1858** (863).

Meteorological Table. The observations of the Thermometer and Barometer extended over a period of 80 years. Plate folding in folio, by B. Woodcroft and J. Glaisher. [1860.]

Instructions for the care, fixing, and management of Coast Barometers, and explanation of the barometer chart. Published by the Royal National Lifeboat Institution, 1861.

The extraordinary Cold Weather at the end of 1860 and beginning of 1861. *Rep. Brit. Met. Soc., London*, **1861** (8-12); also 8°. London, 1862.

On the weather from October 1859 to December 1860. *Rep. Brit. Met. Soc., London*, **1861** (17-34).

The Northumberland Coast Station Barometers. *Life Boat, London*, **4** [1863], (367-371).

The extraordinary Cold during February 1861 in the United States and Canada. *Rep. Brit. Met. Soc., London*, **1861** (56-59).

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Deep-Sea Pressure-Gauge invented by H. Johnson. *Rep. Brit. Assoc., London*, **1861** (part 2), (59-61).

Greenwich Observatory (several papers). *Leisure Hour, London*, **1862**.

Scientific Experiments in Balloons. A Lecture delivered to the Young Men's Christian Association. 8°. London, 1862.

Direction of the Wind at the Royal Observatory, Greenwich, in the twenty years ending December 1860 [1861]. *Proc. Brit. Met. Soc., London*, **1**, 1863 (21-60).

Pressure of the Wind in strong winds and in gales at the Royal Observatory, Greenwich, from the year 1841 to 1860 [1862]. *Proc. Brit. Met. Soc., London*, **1**, 1863 (85-105); *Merc. Marit. Mag., London*, **9**, 1862 (86-88).

Report upon the Meteorology of India in relation to the Health of the Troops there stationed. F°. London, 1863. From Report of the Commission of Inquiry into the sanitary state of the Army in India.

Aerial Navigation, as applied to Scientific Research. *Good Words, London*, 1863.

An account of Meteorological and Physical Observations in eight Balloon Ascents made under the auspices of the Committee of the British Association for the Advancement of Science. *Rep. Brit. Assoc., London*, **1862** (376-503); *Proc. Brit. Met. Soc., London*, **1**, 1863 (234-260).

Lines in the Solar Spectrum, as observed in a Balloon Ascent, March 31st, 1863. *Monthly Not. Astron. Soc., London*, **23**, 1863 (191-192). *Nuovo Cimento*, **17**, 1863 (58-59); *Année Sci. Indust., Paris*, **8**, 1864 (108-112).

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The Gale of October 30, 1863 [1863]. *Proc. Brit. Met. Soc., London*, **2**, 1865 (12-16); *Bull. Intern. Obs., Paris*, Apr. 6, 7, 8, 1864.

Decroissance de la température selon les hauteurs dans l'air. *Année Sci. Indust. Paris*, **8**, 1864 (144-148).

Remarks on the Storms of December 2 and 3, 1863. *Proc. Brit. Met. Soc., London*, **2**, 1865 (48-50).

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Connection between the recent Gales of Wind and the variations of the Barometer. *Life Boat, London*, **5**, 1865 (355-357); *Merc. Mar. Mag., London*, **12**, 1865 (15-17); *Nautical Mag., London*, **34**, 1865 (92-94).

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Notes on his eighteenth Balloon Ascent. *Proc. Brit. Met. Soc., London*, **2**, 1865 (211-213).

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Diurnal Range Tables, newly arranged; containing corrections for Temperature, . . . with similar corrections for the Barometer, etc. 4th ed. 8°. London, 1867.

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The Influence of the Moon on the Direction of the Wind. *Proc. Brit. Met. Soc., London*, **3**, 1867 (359-378).

The Gales and the Variation of the Barometer in the Months of October, November, and December, 1867. *Life Boat, London*, **6**, 1868 (510-512).

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Meteorology of England during the years 1867 and 1868. *Proc. Brit. Met. Soc., London*, **4**, 1869 (306-322).

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Luftreisen. Von J. Glaisher, C. Flammarion, W. v. Fonvielle, und G. Tissandier. 4°. Leipzig, 1872. 2nd ed., 1884.

Snow Crystals. *Leisure Hour, London*, **1872**.

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Photographic Operations at the Royal Observatory, Greenwich. *Photog. J., London*, **15**, 1873 (179).

Thermometer for taking Temperature at the roots of Plants. *J. R. Hortic. Soc., London*, N.S. **4**, pt. 13, 1873 (25-26).

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Comparison of the Atmospheric Pressure in Palestine and in England in the 10 years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1891** (49).

Comparison of the Highest and Lowest Temperatures of the Air and Range of Temperature in Palestine and in England in the ten years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1891** (163).

Comparison of the Monthly Mean Highest and Monthly Mean Lowest Daily Temperatures of the Air, and Monthly Mean Daily Range of Temperature in Palestine and England in the ten years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1891** (224).

Monthly and Annual Mean Temperature of the Air in Palestine and England in the ten years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1891** (302).

Fall of Rain, the Amount of Cloud, the Frequency of Cloudless Skies as recorded at Sarona in the ten years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1892** (50).

Direction of the Wind at Sarona in the ten years ending 1889. *Quart. Statement Palestine Explor. Fund, London*, **1892** (226).

Strength or Pressure of the Wind at Sarona, recorded daily by Herr Dreher in the ten years 1880-1889. *Quart. Statement Palestine Explor. Fund, London*, **1893** (43, 143).

Meteorological Report from Jerusalem for the year 1882. *Quart. Statement Palestine Explor. Fund, London*, **1893** (242); 1883, **1893** (331); 1884, **1894** (44); 1885, **1894** (144); 1886, **1894** (266).

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Results of Meteorological Observations taken at Jerusalem for 1887. *Quart. Statement Palestine Explor. Fund, London*, **1894** (184); for 1888, **1894** (294); for 1889, **1894** (368); for 1890, **1895** (88); for 1891, **1895** (190); for 1892, **1895** (264); for 1893, **1896** (350); for 1894, **1897** (156); for 1895, **1897** (235); for [1896], **1898** (61); [1900-01], **1902** (56, 250).

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Pressure of the Atmosphere at Jerusalem. *Quart. Statement Palestine Explor. Fund, London*, **1898** (21).

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Results of Meteorological Observations taken at Jerusalem and Tiberias in the year 1897. *Quart. Statement Palestine Explor. Fund, London*, **1899** (71); 1898, **1899** (372); [1899], **1900** (286).

Meteorological Observations at Jerusalem. London. Published by the Committee of the Palestine Exploration Fund. [1902.]

At the conclusion of the reading of the paper Mr. MARRIOTT said that Dr. J. W. L. Glaisher, F.R.S., had presented to the Society the instruments used by his father in his famous balloon ascents, and also the marble bust which had been subscribed for and presented to Mr. Glaisher by the Fellows of the Royal

Photographic Society in 1887. In addition to these, Dr. Glaisher had also handed over to the Society several other instruments and a considerable number of books, pamphlets, etc., belonging to the late Mr. J. Glaisher. Mr. Marriott further stated that at the last meeting of the Aeronautical Society he had given an account of Mr. Glaisher's balloon ascents, and that at the conclusion of the same the Secretary, on behalf of that Society, deposited a wreath at the foot of Mr. Glaisher's bust.

Mr. C. HAWKSLEY proposed a vote of thanks to Dr. J. W. L. Glaisher for the generous gift to the Society of his father's bust and ballooning instruments. Mr. Hawksley's father, Mr. Thomas Hawksley, had been associated with Mr. Glaisher more than forty years ago in Parliamentary inquiries in which questions of rainfall were involved, and Mr. C. Hawksley had himself known Mr. Glaisher for many years and passed many agreeable hours with him. Mr. Marriott's reading of a portion of the evidence given at the Parliamentary inquiry recalled to Mr. Hawksley's mind what a rapid speaker Mr. Glaisher had always been—so much so that he was frequently requested in the Committee rooms to speak more slowly, and the shorthand reporters had difficulty in keeping pace with him. Only in the autumn of 1902 Mr. and Mrs. Hawksley paid a visit to him at Croydon, and although then confined to his room by a cold, they had been admitted to see him, and had a very pleasant talk together, Mr. Glaisher exhibiting the geniality and vivacity which had always characterised him. Mr. Hawksley thought the Society much indebted to Mr. Marriott for his interesting paper on Mr. Glaisher and his work.

Dr. R. H. SCOTT seconded the resolution, which was adopted.

Currents in the Arctic Ocean.—At a recent meeting of the Imperial Russian Geographical Society, Mr. Knipovich read a paper on "The Warm Currents in the European part of the Arctic Ocean." As is known, a branch of the so-called Gulf Stream divides into two after rounding the North Cape. One portion goes along the western coast of Spitzbergen, whilst the second, taking a course between the North Cape and Bear Island, penetrates into the comparatively shallow Barents Sea. Here, near to the meridian of Kola, it subdivides into four branches, the southern of which is called by Mr. Knipovich the Murman Warm Current. The author observed that these currents had a very regular and permanent direction. The current going to Spitzbergen sends an under-current to the Storfjord, and, continuing its course, also becomes an under-current near the north-western end of Spitzbergen; afterwards turning to the east, it enters the deep basin which Nansen found to exist in the Arctic Ocean. These observations are in full accordance with the researches of Admiral Makaroff in the *Yermak* in 1899. Concerning the yearly variation of temperature at various depths, Mr. Knipovich obtained the following results. The penetration of heat from the surface is very slow: for instance, along the Murman coast the water at a depth of 200 [656 ft.] or 250 [820 ft.] metres reaches its highest yearly temperature three months later than the surface. Especially slow is the penetration in those parts of the sea which are separated from each other by the rise of the sea-bottom, as, for instance, in some parts of the White Sea. The beneficial influence of these warm currents is best observed in the distribution of ice in the Murman current. The latter forms a barrier against the advance of ice to the south, owing to which the Murman coast is free from the ice coming from the Arctic Ocean.—*Geographical Journal*, December 1903.

REPORT ON THE THUNDERSTORMS OF 1857.

COMPILED BY G. J. SYMONS, M.M.S.

[The following is the *first* paper written by the late Mr. G. J. Symons, F.R.S., and was read before this (then the British Meteorological) Society, on June 9, 1858. It was, however, never printed. As the MS. has recently been discovered among the papers belonging to the late Mr. J. Glaisher, it has been thought that it would be of interest to the Fellows to have this paper in print in the *Quarterly Journal*. The maps referred to in the text have not been found, and therefore cannot be reproduced. It may be added that Mr. Symons was 19 years of age when he read this paper.—EDITORS.]

The results embodied in this paper have been collected from the private reports of the following gentlemen :—G. C. Burder, Clifton ; W. Ingram, Belvoir Castle ; W. R. Milner, Wakefield ; C. L. Prince, Uckfield ; O. Whistlecraft, Thwaite ; G. V. Vernon, Manchester (to whom the compiler desires to express his sincere thanks for the time, etc., they have devoted to the subject)—from the quarterly returns of the Society, from the weekly returns published by Mr. E. J. Lowe, and various other sources. Newspaper reports have not been inserted without corroborative evidence of their veracity.

The stations are inserted in the order of latitude, with a few exceptions where a variation showed the storm's progress more clearly.

The name *only* of a place being inserted in the maps indicates that a storm occurred there on that day. If the time of commencement and ending are known, both are given ; if not, the time on the map indicates the time at which the storm was at its height, except in No. 3, where the times are those of commencement only.

The initial letters **S** indicating a storm or both thunder and lightning,
T „ thunder only,
L „ lightning only,
are used throughout for the sake of brevity.

The red spots on the maps indicate injury being caused by lightning ; the arrow-heads indicate the directions in which the storms are recorded to have moved.

REMARKS ON THE STORMS OF MARCH 31, APRIL 12, AUGUST 13 AND 14.

March 31 (1).

The curves and times given in this storm appear (with the exception of Crewe and Warrington) to indicate most clearly a division of one storm into two branches, the point of separation being near Wakefield. The curve at Thwaite, combined with its non-observation farther south, almost appears an evidence of cyclonic action.

April 12 (2).

The striking uniformity in the times and points of the compass assigned to this storm from the three stations of Uckfield, London, and Nottingham apparently demonstrates the visibility of a storm over a line of country 150 miles in length, and therefore the altitude of the electrical discharges must have been great.

August 13 *and* 14 (3 and 4).

The immense extent of these storms prevented any determination of the direction in which they moved; they appear, however, to have commenced earliest by about two hours at the extreme southern stations ; the mid-day storm was

only noticed in Gloucestershire, Worcestershire, Herefordshire, Leicestershire, and Lincolnshire.

General Inferences.

I. The barometer sustains an average depression of ·11 in. on the day of storm below the day preceding it, and ·12 in. below the day following it.

II. The mean daily temperature of the "day preceding" and "day of storm" are nearly identical, but the "day after" is lower by a mean of 1°·6.

III. The colour ascribed to lightning appears to depend almost entirely on the distance from which it is seen, white indicating the greatest distance, red and yellow intermediate, and blue the least.

IV. The rate of motion or interval between the central passage of a storm over two consecutive stations appears to be about 40 miles per hour; the rate is, however, much raised by the storm of March 31.

V. Particulars more or less complete of the following injuries from lightning are given in the Report:—

4 men killed	13 sheep killed	1 gasometer struck
1 woman killed	2 lambs ,,	1 engine-house ,,
8 persons struck (not killed)	12 trees struck	2 flag-towers ,,
2 horses killed	11 houses ,,	1 mill, 2 ricks ,,
1 cow ,,	2 churches struck	2 vessels (in harbour) struck
1 bullock struck	1 railway station struck	2 barns struck

The principal object the compiler has had in view has been to draw the attention of the Society to this class of phenomena, since if he (one of its youngest and most inexperienced Members) has been able to collect sufficient information to render it worthy the honour of being read before the Society, surely in the hands of influential meteorologists the results would amply reward the time devoted to them.

THUNDERSTORMS IN 1857.

January—

23. **L** Manchester.
25. **S** North Shields. **T** Allenheads. **L** Truro.
26. **S** North Shields.

February—

9. **T** Nottingham—3 p.m., distant.

March—

8. **S** Liverpool; Norwich—3 p.m. (the remarkable "soft hail" fell in London at 3.20 p.m.).
14. **S** Thwaite—accompanied by hail of the size of peas.
15. **S** Clifton—8 a.m.; Chepstow—8.30 a.m., lightning red. **T** Exeter.
18. **S** Preston. **L** Liverpool.
23. **S** Worcester. **L** Little Bredy.
24. **T** Stonyhurst.
26. **L** Maidstone; Clifton—0.30 a.m., in S.
28. **L** Nottingham.
30. **S** Nottingham—2.40 p.m.; Manchester—6 p.m.; Whitchurch, Salop—5 p.m. A waterspout was seen at that place passing from N.E. at 4.35 to S.W. at 4.50, immediately followed by a torrent of rain amounting to ·25 in. in 15 minutes. **T** Worcester; Leicester.
31. **S** Thwaite—first noticed in the W. at 1 p.m., passed over this station about 2 p.m., and disappeared in E.N.E. about 3.5 p.m., although occasional T and L were noted till 7.15 p.m.; Southwold (Suffolk)

—at its maximum intensity at 2 p.m.; Norwich; Belvoir—first noticed in the N. at 12.30. Passed over, striking the Castle flagstaff and igniting a mill in the vicinity, about 1.30. It passed to S.E. at 3.15. The L is described as intensely blue; Grantham—lasted from 1 till 2.15 p.m., passing in N.W. current; Nottingham—lasted from 11.45 a.m. till 2.45 p.m., passing in N.W. current; Manchester—first noticed at 9 a.m. in N.E., it passed towards the S.W. at 2 p.m. Its intensity only lasted from 1 till 1.40 p.m. The lightning was red; Mansfield—at 0.30 p.m.; Crewe—at its maximum at 4.30 p.m.; Warrington—lasted from 5 to 6 p.m. **T** Stonyhurst; Leicester. **L** Bedford.

April—

2. **S** Holkham.
3. **T** Bywell.
5. **T** Belvoir; Nottingham.
7. **S** Lewisham—4 till 4.50 p.m. (slight); Worcester; Norwich; Leicester—2 p.m., in a W. current.
8. **T** Nottingham; Stonyhurst; Scarborough.
9. **S** Belvoir; Grantham; Nottingham; Manchester; Silloth—5.30 p.m.
10. **S** Worcester; Leicester; Belvoir; Nottingham; Grantham; Manchester; Wakefield; North Shields. **T** London—5.40 p.m.; Hartwell—in W. at 5 p.m. This storm was exceedingly productive of trifling accidents. Among the more important were the following:—The house of Mr. T. P. Ramsden of Pontefract (Yorks) was struck, the current dividing into two portions. One descended a chimney and struck Mr. Ramsden, who was standing by the fire, and also his daughter, who was sitting near him. Mr. Ramsden was not much injured, but his daughter was prostrated with great violence, rendered blind and insensible, and lost the use of her feet; she recovered, though but slowly. The other current passed down a water-pipe as far as an iron holdfast, which conducted it through the wall into a room, to the furniture of which it did considerable injury. At Hill Dyke Bar, near Boston, the house of Mr. Morley was struck. The gable end being demolished the current entered the house, injured three of the servants, and killed a cat. At Luffenham, near Stamford, a house was ignited and almost wholly consumed.
11. **S** Hastings. **L** Little Bredy; Royston.
12. **S** Uckfield—from 9 till 10 p.m., and from 12 till 1 a.m. (13th); London—from 8.50 till 9.15 p.m., in E., S.E., and S.; Berkhampstead; Nottingham—from 9 till 9.30 p.m., in S. and S.E.; Grantham. **T** Clifton; Belvoir. **L** Exeter; Ryde; Hastings; Little Bredy; Oxford; Hartwell; Knebworth; Cardington.
14. **S** Ryde.
15. **S** Exeter. **T** Maidstone; Hartwell; Knebworth; Cardington.
16. **S** Exeter—the lightning struck a boy named William Bowden while wheeling a barrow in a stonemason's yard, and paralysed his left eyelid without injuring the eye. His brother, who was standing near him, was struck, and swooned, but received no permanent injury. **T** Little Bredy; Sharnbrook.
25. **L** Holkham.
26. **T** Helston. **L** Holkham.
29. **T** Sharnbrook.
30. **T** Little Bredy. **L** York.

May—

1. **T** Durham. **L** Oxford.
2. **T** Little Bredy ; Clifton.
7. **S** Norwich.
10. **T** Hastings.
11. **S** Hastings ; Gloucester ; Berkhampstead ; Hartwell ; Bedford (vivid L). **T** London—3.25 p.m. ; Ware—5 p.m. ; Kew. **L** London—9 till 10.15 p.m. ; Maidstone ; Oxford ; Bedford ; Cambridge.
12. **T** Norwich, in evening.
13. **L** Clifton ; Worcester.
14. **S** Hastings ; Little Bredy ; Worcester ; Nottingham—in W. and N.W. from 7.45 till 8.45 p.m. ; Manchester—8 p.m. ; Liverpool ; Wakefield ; Stonyhurst ; Silloth—6 p.m. **L** Exeter—10 p.m. ; London—10 p.m. ; Ware—9.50 p.m. ; Clifton ; Oxford ; Maidstone ; Gloucester ; Cardington. **T** Durham.
15. **S** Bedford (at night) ; Oxford ; Stonyhurst. **L** Exeter—10 p.m. ; Little Bredy ; London—9.20 till 10.40 p.m., in S.W. and S. ; Aldershot—evening ; Ware—11 p.m. ; Berkhampstead ; Gloucester ; Nottingham—evening. **T** Hartwell ; Leeds ; Durham.
16. **S** Royston ; Hartwell. **L** Greenwich.
18. **T** Royston.
20. **S** Worcester. **T** Oxford. **L** Maidstone ; Cardington.
21. **T** Ware, 7.45 p.m.
22. **T** Bywell.
23. **S** Hastings.
25. **S** Maidstone ; Nottingham—storm passed from S. to W. at 2.30 p.m. ; Wakefield ; Leeds ; Stonyhurst. **T** Hastings ; Rose Hill.
28. **S** Clifton—commenced in S.E. at 4.30 p.m., passed over this station at 5.40, at which time the lightning was beautifully seen against a dark cloud in the W. ; its colour was yellow, and its character "jagged horizontal streaks."
30. **S** Exeter.

June—

3. **S** Belvoir ; Nottingham ; Wakefield.
5. **S** Gloucester ; Cheltenham—from 11 p.m. till 2.30 a.m. of the 6th ; Bicester ; Sharnbrook ; Leicester—10 p.m. ; Liverpool ; Nottingham—from 0.0 till 2 a.m., 6th ; Wakefield ; Scarborough ; North Shields. **L** Clifton—in N. from 10 till 11 p.m. ; London—9.55 p.m. ; Oxford ; Hartwell ; Knebworth. **T** Little Bredy ; Durham ; Allenheads.
6. **S** Gloucester ; Berkhampstead ; Thwaite—commenced in S.S.W. at 2 p.m., passed by S. and S.E. to E. at 4 p.m. The lightning was of two kinds, "sheet, which was red, and curved lines, which were blue" ; Boxford—first noticed at 2.30, ended at 4 p.m. ; Norwich ; Nottingham. **T** Greenwich. **L** Lewisham ; Rose Hill.
10. **S** Uckfield—two distinct storms passed over this station. The first was noticed in the N.W. at 0.30 p.m., its intensity was reached at 0.45, and it disappeared in the S.E. at 1 40. The second commenced in the W. at 2.35, becoming most violent at 3.3 ; it also disappeared in the S.E. at 3 40 p.m. The L in the first was whitish, and in the second bluish sheet ; Berkhampstead ; Gloucester ; Hartwell ; Bedford ; Thwaite—passed from W. to E., and though its intensity did not last more than 45 minutes it committed sad havoc, striking several buildings and shattering

numerous trees. The L was forked and yellowish. **T** Hastings; Rose Hill.

11. **T** Norwich.
12. **T** Norwich.
16. **S** Inkpen, near Hungerford, Berks—two men, Joseph Buxey, aged 56, and George Palmer, aged 26, were mowing in the park of Mr. John Butler with one other man. When the storm commenced Buxey and Palmer took shelter under a large lime tree, one of a row on the lawn, their companion went to a cottage and was saved. From the appearance of the tree, the fork of L divided into two, one going to each man. When found, immediately after the storm, they were both quite dead, the clothes of one on fire. No other tree was struck, nor had they anything with them to attract the lightning; Bicester; Hartwell; Sharnbrook. **T** Berkhampstead.
17. **T** Little Bredy.
18. **S** Little Bredy.
19. **S** Exeter; Hastings; Clifton—commenced at 7.20 p.m. and lasted till midnight, the lightning being very vivid and followed by T in 4 seconds. Course of storm doubtful, but probably from S.E.; Little Bredy; Maidstone; Uckfield was visited with a succession of storms lasting from 3.40 p.m. till 1.15 a.m (of the 20th), the L was intensely blue and very forked; Blackwater (Hants); London—slight at 7.55 p.m. At 11 p.m. an electrical cloud was observed in S., the L from which was whitish and the flashes averaging 12 per minute. About 11.50 it appeared to divide into two portions, one passing to S.E.; the L changed to a yellow tint, decreased in strength, and disappeared at 0.45 a.m. The other portion advanced towards this station and became "rose, violet, and blue." It was mostly sheet, and disappeared in N.W. at 2.50 a.m. (20th); Oxford; Hartwell; Knebworth; Gloucester. **T** Helston; Falmouth.
20. **S** Hastings; Blackwater; Clifton—from 9.30 till 11.30 p.m., in N.W.; London—in S.S.E., from 7.10 till 7.45 a.m., thunder loud; Oxford; Berkhampstead; Hartwell; Gloucester; Royston; Bedford. **T** Nottingham—4 a.m., and at intervals till 8.30 p.m.; Helston. **L** Exeter; Little Bredy; Maidstone; Ambleside—in evening, in E.
21. **S** Maidstone; London; Hartwell; Gloucester; Nottingham—0.0 till 3 a.m., 22nd. **T** Oxford; Berkhampstead.
22. **T** Bicester.
23. **T** Oxford.
24. **T** Allenheads.
27. **S** Ryde. **L** Helston.
28. **S** Hastings; Thwaite—9 p.m., in N.E.; Norwich; Nottingham—in W. at 5 p.m., from 10 p.m. constant L in N.E. and S.; Liverpool; Wakefield — 6 p.m.; Stonyhurst; York; Scarborough. **T** Greenwich. **L** Bedford; Belvoir.
29. **S** Worcester; Nottingham—from 2.45 till 4.15 p.m., much T in W. and S. Storm moved in S.W. current; Liverpool—heavy storm from about 8 to 10 p.m., T loud, L forked and vivid; Manchester —at 3.30 p.m. Dense masses of cloud gathered in S. at 8 p.m., L commenced at 8.20, T at 8.30, and from this time till 9.17 the S was at its height, the time-interval being about 7 seconds. It

ceased at 10.26, having passed by W. to N.W. The L was mostly forked, and its colour "white, tinted with red and orange"; Wakefield—commenced in S. at 4 p.m., at its height about 5.5, and disappeared in N. at 5.30. The L was mostly "forked, rose-colour"; Stonyhurst; York; Scarborough. **L** Hastings.

30. **S** Oxford; Royston; Bedford; Worcester; Thwaite—it commenced in S.W. at 2.40, arrived at this station at 4.15, and passed on to N.E. at 5 p.m. The colour of the L was "pale blue, generally curved"; Nottingham—2 p.m. Much T in E. from 2.30 till 3.30. The S was nearly overhead, there being five flashes within half a mile of this place; Liverpool—raged violently from 10 a.m. till noon. The house of Mr. Kelly, Five Elms, Aigburth, was struck by L; it tore off part of the roof of the house, and, passing down the chimney into the sitting-room, caused considerable injury. The electric clock on the Exchange stopped.

July—

1. **S** Falmouth; Maidstone; Little Bredy; Uckfield—violent S passed to the N.E. of this station between 2 and 4 p.m.; London—commenced in N.W. at 10.50 a.m., passed N. of zenith to W.S.W. at noon. The L was mostly sheet, and of a pale reddish tinge. **L** Helston; Lewisham; Greenwich; Oxford.
4. **S** Manchester—very violent from 5 to 6 p.m.; Wakefield; York; Scarborough. **T** Oxford.
5. **S** Falmouth; Fairlight; Clifton—moving from S.W. from 5.50 to 6.10 p.m., time interval 8 seconds; Oxford; Gloucester; Bedford; Worcester; Grantham; Scarborough.
6. **S** Hastings; Clifton—from 4 to 5 p.m. a S passed from W.N.W. to N.E. At 4.43 a flash of L was seen to cross the sky diagonally to a point in W.N.W., where it struck a house (half a mile distant) and knocked down the chimney. From 5 to 6 p.m. another distinct S passed in the same direction; Oxford; Hartwell; Gloucester; Hereford. **L** Uckfield—distant, in evening, in S. and S.E.; London—9.55 p.m. **T** Scarborough.
7. **T** Thwaite—distant.
10. **S** Burton (Lincoln)—very violent in afternoon; Nottingham—4.30 p.m.; York; Bywell; Berkhampstead; Grantham; Belvoir.
15. **T** Hastings; Thwaite—distant.
16. **T** Hastings; Thwaite—distant.
18. **T** Little Bredy.
19. **T** North Shields; Bywell.
27. **S** Oxford; Gloucester—5 p.m.; Cardington; Hereford. **T** Thwaite—distant; Leicester—4.45 p.m.; Belvoir.
28. **S** Lewisham; London; Sharnbrook. **T** Berkhampstead.

August—

4. **S** Hastings. **T** Little Bredy; Maidstone; Uckfield—in S. and S.E. at noon.
5. **S** Maidstone; Uckfield—violent at night. **T** Helston; Oxford.
6. **S** Falmouth; Helston; Hastings; Royston; Bedford—3 a.m. **T** Teignmouth; Little Bredy; Clifton—2.30 till 2.45 a.m.; Hartwell; Holkham. **L** North Shields.
7. **S** Royston; Nottingham—loud T at 2 p.m., vivid L in N. from 10 till 12 midnight, the T being scarcely audible. **T** Thwaite; Norwich—12 noon. **L** Grantham—much L during the night.

8. **S** Clifton—from noon to 7 p.m. a succession of very violent storms with heavy rain; Gloucester — 2 p.m.; Sharnbrook; Belvoir; Nottingham—from 10 a.m. till 2 p.m.; Durham—in the afternoon. **T** Oxford; Thwaite; Norwich; Manchester; Wakefield; North Shields.

9. **S** Hastings; Uckfield—commenced in N.W. at 10.45, and passing over this station disappeared in S.E. at 3 p.m. The colour of the L was "reddish sheet." A horse and a brood of chickens were killed in the adjoining parish on the W., and a tree was shattered in an adjoining parish on the E.; London—2.22 to 2.45 p.m., from a S passing from N.W. to S.E.; Nottingham—heavy at 10.30 a.m., and at intervals till 5 p.m. **T** Greenwich; Bicester; Berkhampstead; Gloucester; Belvoir.

13. **S** Exeter; Little Bredy; Newport and Ryde—began at 7 p.m.; Southampton—at a few minutes to 7 p.m. a storm-cloud approached from S.E., while another met it from N.E. After the union of the two storms, the L continued almost without ceasing for 2¼ hours; Shirley—it was also very violent. A report was circulated that a lady was struck dead by L, but she in reality died of an affection of the heart brought on by fright; Romsey—excessively violent. The hail descended with such force as to strip several acres of barley; Arundel—a tree struck near the bridge, and also some masts of vessels; Climping—an outhouse struck and ignited; Goodenweek, near Lewes—a barn belonging to Mr. Croomer, containing five loads of wheat and fifteen waggon loads of trefoil, was struck and destroyed; Woolston—S lasted in its full intensity from 7 to 9 p.m. A vessel had her topmast shivered, and the house of Mr. Baker was injured; Uckfield—L first noticed in S. and S.W., which soon extended to W., N.W., and N., without passing over this station. Occasional T and L all night; Petworth—the T and L lasted almost incessantly from 8 p.m. till 3 a.m. on the 14th; Rogate—it commenced about 6 p.m., and from 8 to 9.30 p.m. was "truly terrific"; Steep (Hants)—a young woman was struck in the arm and much injured; Guildford—began at 7.30 p.m.; Alton—8.45 commenced; Aldershot—storm-cloud noticed to come from N.W. at 7.50, first T and L at 8, and within an hour 1 in. of rain fell, and 1000 flashes of L were counted in the same time, accompanied by tremendous T. Ceased at 3 a.m.; York Town—commenced at 8 p.m. and lasted without intermission till 3 a.m. The L was incessant in four distinct places at once, each of a different colour; Yately—a house struck and ignited; Reading—very violent, L intensely vivid, and incessant rain. The engine-house of Messrs. Barrat, Exall, & Co. was struck and (I believe) considerably injured; Clifton—from 3.30 to 5 p.m.; Slough—began at 7 p.m.; Windsor—L struck the flag-tower of the Castle, displacing about four tons of the parapet, but fortunately did no damage to any other part. One of the trees in the Home Park, nearly opposite the residence of the Duchess of Kent, was struck and much of the bark stripped off. An elderly female named Wilkins was found dead in her bed, supposed to have been caused by fright; Lewisham; Greenwich; London—Shadwell—the residence of Mr. Nicholls, builder, was struck, and a stack of chimnies destroyed; Clapham—first noticed in S.W. and N.W. at 8.30 p.m., from that time increasing in violence till 1.30 a.m. (14th); Whitehall—noticed at 6 p.m., raged violently

till 3 a.m. (14th), but at a few minutes to 2 a.m. a remarkably loud clap of T; Pimlico—first noticed in N.W. at 8.50 p.m., passed over the zenith and disappeared in S.E. about 0.0. At 0.35 a.m. (14th) it recommenced, the T being much louder than in the first S. The L was principally bluish white, blue, and violet. A tree in Kensington Gardens, distant about 100 yards from the Palace, was struck, and slight charges passed down each side of it, tearing off the bark and cutting a groove $\frac{1}{4}$ in. deep and $\frac{1}{2}$ in. broad in the solid wood as cleanly as if done with an instrument. It was the last tree of a long avenue; Tottenham—from 8.15 p.m. much L, but neither T nor rain till 9 p.m. Very violent till about 11 p.m., when it subsided for a short time. It commenced again, however, at a later hour, apparently as violent as before; Chelmsford; Berkhampstead—lasted from 9 p.m. till 2 a.m. (14th); Nuneham Park, Oxon—an oak tree, the trunk of which was over 3 ft. in diameter, was entirely severed and denuded of bark. The upper part fell into and remained firmly fixed in a cleft in the lower, while the branches and bark were scattered around, some of the fragments at considerable distances; Hartwell; Bicester; Royston; Gloucester—very severe, commenced about 4.30 p.m.; Cardington; Worcester—very violent; Bedford—commenced about 9 p.m. and continued till after 2 a.m. (14th); Hereford—from 10.30 a.m., distant T increasing (with L) and approaching till noon, when the time interval was but a few seconds. It then suddenly subsided, and was followed by bright sunshine till 2 p.m., when it recommenced and lasted till between 7 and 8 p.m. L very vivid, forked, and of a golden colour; Widfield Park—a large oak was struck and shattered; Ross—very violent, the hail resembling large pieces of ice; Ludlow—violent S in the afternoon; Cambridge; Leicestershire must be taken as a whole, as the S swept over its entire extent, the most southerly parts suffering least. There appears to have been two distinct storms; the first at its maximum at 2.5 p.m., and the second at 8.15 p.m. The following list gives a mournful view of the effects of one day's storm. Two men—John M'Ginn, aged 18, and Henry Rafferty, aged 24—were reaping in a field at Woodhouse Eaves. The rain coming on very heavily, they took shelter under a tree. When found, they were both quite dead; the hair, whiskers, eyelashes, and eyebrows being singed off, and a long mark of discolouration extending down their backs. The tree was scarcely injured. A man named Symonds, at Cropstone, was struck, but though dangerously hurt he was expected to recover; Ullesthorpe—the L struck the chimney of the house of a man named Sutton. Descending the chimney it melted the bottom of a brass candlestick standing on the mantelpiece. A barn struck and burnt down at Hose; Wartnaby—the gable end of Mr. Esson's house fell outwards with a fearful crash (the action of L in this case is doubtful); a chimney knocked down at Long Clawson; at Ab-Kettleby a tree was struck by L, and the top driven a considerable distance into the ground, while the trunk was shattered to splinters; Evington—the Keck's Arms was struck but not much injured; Keyham—Mr. T. Miles had a horse, value £40, killed in a field; Knighton—an ash tree was struck, stripped of the bark on both sides, and a rabbit found dead beneath it; Belvoir Castle—a most singular phenomenon was seen at this station, viz. the

passage of one storm-cloud beneath another. The resulting appearance is described as "like thousands of furnaces vomiting forth smoke and flames." The L was remarkably brilliant all night, the colour mostly blue. A bean-stack was struck in the vale; Grantham —commenced at 3 p.m., and lasted in greater or less intensity till after midnight; Derby — violent; Nottingham—the first S began at 1 p.m. and lasted till 2.30 p.m. L yellow from this time till 6.30 p.m. Distant T was almost incessant, with L from that time till 8 p.m. At 9 p.m. almost constant L (averaging fifteen flashes per minute) till 11 p.m., the colour being a brilliant blue. The rainfall from 9 a.m. till 9 p.m. was 2·9 ins.; Spalding; Boston; Louth; Retford; Manchester—began about 8 p.m., the L appearing in three places at once, and the rain descending in torrents; Bawtry; Doncaster; Epworth; Brigg; Wakefield; Scarborough; Silloth—S commenced about 9 p.m.; Bywell.

14. **S** Exeter; Hastings; Coldwaltham—the church struck and injured; Uckfield—with loud T at 3 p.m. Heavy showers north of this station; Horsham was visited with rather a severe S in the evening. An oak tree on the estate of Mr. C. S. Dickens was split into a number of pieces, some of which were thrown a considerable distance; Dover—slight S at 5 a.m. and in evening; Aldershot—violent S from 5.30 p.m. till 8 p.m.; York Town—from 5 till 7 p.m.; Reading; Clifton—from 11.30 a.m. till 3 p.m. Loud T, but only one flash of lightning; London—Clapham—S at 1.30 p.m.; the Bricklayers' Arms Station of the South-Eastern Railway Company was struck about 2 p.m., and a little before 4 p.m. about 300 ft. of the iron roofing gave way and fell in with a tremendous crash; Whitehall—the S began about 6, and from 8 till 11 was very violent; Pimlico—storms at 5.40 and 6.20, and a violent one from 9 to 11 p.m., the L being violet and beaded; Spitalfields—10.15 p.m. The L struck one of the iron columns supporting a gasometer at the Chartered Gas Company's works, in consequence of which the gas, amounting to many hundred thousand feet, became ignited, and it is only due to Mr. Upward, the resident manager, to state that, had he not taken the steps he did, a fearful explosion must have ensued; Bedford—S lasted from 6 to 8.30; Leicester—8 till midnight; Kibworth, near Market Harborough—a chimney struck, but not much injured; Stamford—the L struck (11.30 a.m.) the pinnacle of St. Michael's Church and totally destroyed it; Norwich—heavy S in evening; Belvoir—S passed from S.E. to N., being most violent at 10.25 p.m. The L was principally blue. A cow was struck dead; Derby—violent from 8 to 11 p.m.; Nottingham—violent S, beginning at 9.25, lasting till after midnight; Grantham—S at its maximum at 10.15 p.m.; Lincoln—very violent S, accompanied by deluges of rain which seriously injured the railways. On the Nottingham and Lincoln branch upwards of a mile was rendered impassable; Manchester appears to have been most severely visited, it lasting from 9 till 11 p.m. Many lives were lost by inundations. The reservoir at the Blue Pits burst. The river Medlock overflowed its banks and caused damage to the estimated extent of £40,000 to £50,000. The house of Mrs. Ovy, Chorlton on Medlock, was struck and set on fire. The property was, however, saved, with trifling damage; Farnley, near Huddersfield—a woman named Betsy Farrand was struck and killed while sitting in her chair.

15. **S** Falmouth ; Uckfield — from 11.50 p.m. till 0.15 a.m. (16th); Dover—violent at night ; Hastings ; Maidstone—11 till 12 p.m. **T** Sharnbrook ; Doncaster.
16. **S** Ryde.
19. **T** Helston ; **L** Nottingham—in N.E. in evening ; Wakefield.
21. **L** Exeter.
22. **S** Falmouth—in evening ; Exeter. **L** Little Bredy. **T** Silloth.
23. **L** Helston.
24. **T** Liverpool. **L** Stonyhurst.
31. **S** Maidstone ; London—2.50 p.m. (slight). **T** Rose Hill.

September—

1 **S** Boxford (Suffolk)—with very heavy rain at noon. **L** Aldershot—in evening.
2. **S** Cardington ; North Shields ; Allenheads. **T** Nottingham—at 4.30 p.m.
3. **S** Fairlight ; Maidstone ; Liverpool ; Allenheads. **T** Helston—at noon ; Norwich. **L** Little Bredy.
4. **S** Little Bredy ; Silloth—at 11 a.m., from the N. with heavy rain and hail for 30 minutes, at 5 p.m. T and L in W. ; Durham—9 a.m. ; Bywell ; Allenheads. **T** London—at 2.12 p.m. **L** Scarborough.
5. **S** Silloth—10.20 a.m. from W. ; Nottingham—11.30 a.m. ; York ; North Shields ; Durham — in the afternoon. **T** Fairlight ; Bywell ; Allenheads.
6. **S** Maidstone ; Norwich ; York ; Grantham. **T** Fairlight ; Belvoir. **L** Cardington ; Nottingham—in evening ; Scarborough ; North Shields.
7. **S** York. **L** Scarborough.
8. **S** Fairlight ; London—at 8 p.m. in E.S.E. ; Liverpool.
9. **S** Maidstone ; Bywell. **T** Liverpool.
10. **L** Clifton—at 2.30 a.m., rather vivid.
11. **T** Fairlight ; Little Bredy.
12. **T** Fairlight.
24. **S** Rose Hill ; Royston ; Cardington ; Worcester. **L** Fairlight ; Maidstone—at night ; Little Bredy.
25. **S** Norwich. **T** Holkham.

October—

4. **S** Cambridge—in morning and afternoon ; Heigham Hall, Suffolk—13 sheep are stated to have been killed beneath one large tree ; a tree at Dedham was also struck. **L** Wakefield ; Scarborough ; North Shields ; Allenheads.
5. **S** Little Bredy ; Clifton—from 4 to 7 p.m., a succession of storms passing across the N.W., T rather faint, L in W.N.W. till 9.30. **T** Liverpool. **L** Scarborough ; Allenheads.
6. **S** Truro. **T** Little Bredy. **L** Helston ; Clifton—in S.E. at 3 a.m. ; Cambridge—at night.
9. **S** Liverpool.
20. **T** Fairlight.
21. **T** Gloucester—at 3 p.m.
22. **S** Berkhampstead. **L** Fairlight.
23. **L** Helston.
28. **S** Royston.

November—

2. **L** Hartwell.
3. **S** London.
4. **L** Helston.
6. **S** Fairlight.
12. **L** Helston.
22. **S** Helston.

December—

16. **L** Greenwich.

Evaporation from the Land.—In the Note of Mr. Fitzmaurice's Report on the "Shrinkage of the Thames and Lea" which appeared on p. 179, vol. 29 of the *Quarterly Journal*, it is stated that an allowance of 70 per cent has been made for evaporation, etc.

It has always seemed to me that it would be more correct to speak of evaporation as a fixed sum in inches, as one does rainfall.

If the rain falls in showers of short duration with bright intervals, there will probably be a point below which a decrease in rainfall will have a

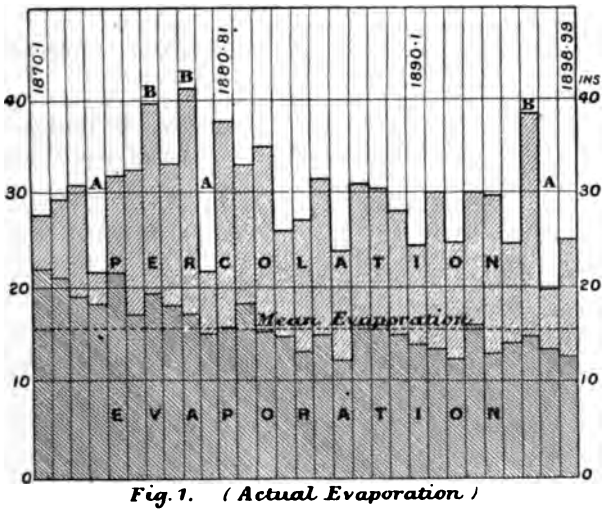


Fig. 1. (Actual Evaporation.)

corresponding decrease in evaporation. On the other hand, in a long-continued rain, the more of it, the less evaporation. Again, if a year's rainfall is largely made up of summer showers, there will be much more evaporation and less percolation than if the same quantity fell during the winter. The above is an *a priori* way of looking at it, but the factors of the case are so complex that it cannot be expected to give a very satisfactory result, and one is reduced to *a posteriori* methods.

On p. 143, vol. 26 of the *Quarterly Journal* is a table giving results of 29 years' percolation experiments at Rothamsted. It is not said whether there was any flow-off from the surface of the gauges used, and it is assumed there was not, and consequently if we deduct the percolation from the rainfall we obtain the evaporation. This I have done, and plotted a diagram showing the rainfall, evaporation, and percolation. In Fig. 1 the upper line represents the

rainfall and the lower line the evaporation, the distance between them giving the amount of percolation. Now if the evaporation were a percentage of the rainfall, the evaporation curve would be similar to the rainfall curve but less accentuated, and the extra low rainfall years A A A would show extra low evaporation, and the extra high rainfall years B B B would show extra high evaporation. But none of these things appears to show any tendency to happen —indeed the evaporation curve shows, to one accustomed to the inconsequence of rainfall statistics, a pleasing uniformity. The only striking point about it is that it shows a decided tendency to drop, indicating a yearly decreasing evaporation. Indeed, if an equalising curve be drawn along the evaporation line in Fig. 1 it will be seen that the yearly evaporation falls steadily from 21 ins. in 1870-71 to 13 ins. in 1898-99. It is difficult to say what can be the cause of this: it does not appear to drop with the general decline in rainfall—see the first few years. Is the yearly sunshine decreasing? Is the proportion of winter rain increasing? Or is some continuous change taking place in the filling material of the gauge? Or is something wrong with the gauge itself?

In Fig. 2 the lower line has been obtained by taking the evaporation as a uniform percentage (54 %) of the rainfall, and it will be seen at once that in

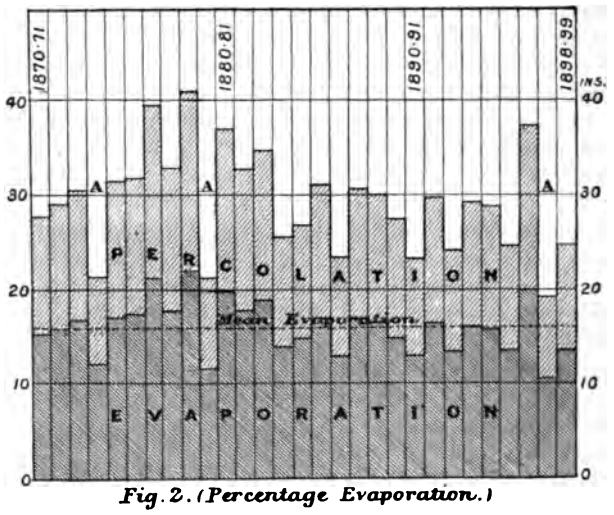


Fig. 2. (Percentage Evaporation.)

the three minimum rainfall years A A A, the years of most importance to engineers, the figure for percolation obtained by this means would be about twice the actual percolation.—L. GIBBS.

Meteorological Society of Japan.—We have recently received several numbers of the *Journal of the Meteorological Society of Japan* for the year 1903. The Meteorological Society of Japan was founded in 1882, and at the present time has more than 260 members. The President of the Society is His Excellency Vice-Admiral Viscount Venomoto. Its publication is the *Kishoshushi* (Meteorological Journal), of which more than 180 parts have already been published. The language used in this Journal has hitherto been exclusively Japanese, but in the future it is intended to insert occasionally articles on Japanese meteorology as well as other scientific matters in English, French, and German. The titles of articles appearing in this publication will be found in Meteorological Literature (p. 99).

ON CERTAIN RELATIONSHIPS BETWEEN THE DIURNAL CURVES OF BAROMETRIC PRESSURE AND VAPOUR TENSION AT KENILWORTH (KIMBERLEY), SOUTH AFRICA.

By J. R. SUTTON, M.A., F.R.Met.Soc.

[Read December 16, 1903.]

The pressure *minus* tension theory is not now strongly held, nor does the $p - t$ column appear as frequently as of old in the registers. Broun practically demolished it in the middle of the last century,[1] and although a few later eminent writers upon meteorology, Sir John Herschel among the number, looked upon it with some favour,[2] the cult was of a vanishing order of small quantities. Dove claimed that by correcting the barometric pressures for vapour tension, thus reducing to the "pressure of dry air," the resulting curves were simpler. The claim may be as open to dispute as the theory. As to the latter, it seems that the strongest argument against it is derived from observation, from the now well-known fact that it is not unusual, in passing upwards through the air, to encounter strata more or less damp than those beneath.

There was an interesting discussion some forty years ago, in the *Proceedings of the British Meteorological Society*, vols. 1 and 2, between Lamont, Airy, and Bloxam. Lamont thought that he had found "the direct proof that *Dalton's Laws contain an essential error.*" And Airy, who assisted with some energy the publication and circulation of Lamont's paper, remarks that "as far as observations have enabled me to form an opinion, I assent entirely to the views of Dr. Lamont." But it is difficult to decide what was the exact ground of Lamont's objection. From one point of view he seems to have concluded that because it is possible to devise an experiment in which air and vapour may be in contact and yet not readily mix, therefore Dalton was fundamentally wrong; from another that the laws were applicable to small spaces, such as under the receiver of an air-pump, say, but failed in the free atmosphere because water vapour is not distributed in the same manner as it would be if it were an atmosphere independently existing.

In later times Scott has reaffirmed some of Lamont's views:—

> Kaemtz showed that in September and October 1832, the vapour-pressure at Zurich was 0·366 in.; while at the Faulhorn, at the height of 8400 feet above the sea, it was only 0·162 in.; and this proportion was kept up in the succeeding year, which was a wet one, while 1832 was dry. It has been calculated that one-half the quantity of vapour in the air is contained in the lowest 6000 feet of the atmosphere, and that the amount contained above the level of 20,000 feet is only one-tenth of that at the surface of the ground. In fact, the vapour in the atmosphere decreases much more rapidly than would be the case in an independent vapour atmosphere existing under its own pressure,

[1] See *inter alia* the British Association *Report* for 1859.

[2] ". . . the diurnal oscillations (or, as they have sometimes though improperly been called, 'atmospheric tides') which have a good deal perplexed meteorologists, but whose analysis, into what we have for convenience called wet and dry pressure, has happily been suggested by M. Dove as affording a rational explanation."

as has been shown by Lieutenant-General R. Strachey (*Proceedings of the Royal Society*, vol. 11, p. 182). This diminution of vapour-pressure does not proceed at a uniform rate, for in Daniell's *Meteorology* we have an account of an ascent of the peak of Tenerife, by Captain Basil Hall, who found that he passed through successive strata of vapour—"vapour-planes," as Herschel has called them. After getting wet through at Orotava Captain Hall found the air very dry at the summit of the mountain, but on descending he re-entered the damp stratum at the lower level. This experiment has unfortunately not been systematically repeated, but it is confirmed by occasional observations in balloons. These considerations are, however, sufficient to show that we are not safe in drawing precise conclusions as to the amount of vapour in the atmosphere at large from isolated hygrometrical observations taken at the surface of the earth. But in a general way, it has been inferred by Strachey from observations, and by von Lamont from theoretical considerations, that the actual tension of the vapour existing in the atmosphere is only about one-fourth of that observed at the surface of the ground.

This shows us that Dalton's law, that gases mixed together exert each its own pressure independently of the others, is not applicable to the mixture of dry air and aqueous vapour in the atmosphere, although the law is strictly true in the case of a confined portion of damp air, such as may be made the subject of a physical experiment.

The reason of this difference is that the relations on which the law is based can only hold good when the air and vapour are uniformly mixed throughout the entire extent of the atmosphere—a condition which, as we have just seen, is not fulfilled in nature.[1]

As a matter of fact, however, Dalton's laws themselves furnish the complete answer to these criticisms. The atmospheric shell of aqueous vapour is not distributed in the same manner as it would be if there were no atmosphere of dry air, because the presence of the latter checks the rate of diffusion of the vapour; but, nevertheless, the mixture is ever tending to the experimental result. It is not really necessary that the air and vapour be perfectly and uniformly mixed, even in Dalton's own apparatus. Preston proves that the formula $P = \Sigma p$ is true for any number of gases, whether they be each diffused throughout the containing space, or superimposed in layers. And undoubtedly it is immaterial to the argument whether the sides of the containing space are of glass or of the surrounding air.[2]

Bloxam's contribution to the original controversy was a very able defence of the physical laws. He made it pretty clear, eventually, that Lamont was confusing what Dalton had proved with what some meteorologists thought to be a necessary consequence thereof. Indeed, Lamont had not invalidated the laws, but by a circuitous route had arrived at the insufficiency of the $p - t$ theory previously insisted upon by Broun and others. Not because Dalton was wrong, therefore, but for quite another reason, "we learn that it is incorrect to assume that the

[1] Scott, *Elementary Meteorology*, pp. 111-113. It appears, nevertheless, that a formula based upon the difference in temperature between the air and the dew point near the ground furnishes an easy and fairly trustworthy method of determining the height of clouds which lie below 5000 feet. It follows, therefore, that the "vapour-planes" are more incidental than general. See the Blue Hill *Observations* for 1896; also W. M. Davis, *Elementary Meteorology*, p. 163.

[2] *Theory of Heat*, p. 351. See also Dalton, *Meteorological Observations and Essays*, 2nd ed., p. 130, footnote; Shaw, "Report on Hygrometric Methods," *Phil. Trans.* vol. 179, p. 74.

amount of vapour-tension at the earth's surface may simply be subtracted from the barometrical reading in order to obtain the pressure of the dry air alone." The vapour, in fact, because it requires time to percolate into the surrounding air, is locally and temporarily compressed.[1]

The mean annual hourly values of the harmonic constituents of barometric pressure and vapour tension (approximate) for Kenilworth (Kimberley) are given in columns 4 and 8 of Table I. Here V_1 for the barometer is probably largely a thermal result, and does not indicate any increase in the total mass of air overhead; while the corresponding angle in the vapour tension series depends largely on sun and wind. But the phases of the second, third, and fourth harmonic terms are so closely concordant in each series that the tension terms are almost certainly portions of the total pressure terms. Indeed it must be evident that any increase in the quantity of ordinary unsaturated air in a given space must increase the amount of vapour in that space in the same ratio, and therefore all mechanical movements, as distinct from thermal actions, of the atmosphere, must include collateral movements of the contained vapour.

This being granted, we see that the third and fourth terms of vapour tension are almost exactly three times as great in amplitude as those of the total pressure—a result that of itself, apart from the facts of observation, would be fatal to the Dove reduction.

Now it seems not unlikely that if the air were dry, the night minimum of the barometer would nearly, if not quite, vanish. Not that it is directly due, as Buchan argues, to the evaporation and condensation of moisture, but rather to some wider and more complicated mechanical action in which the aqueous vapour plays its part.[2] And from this point of view it is not improbable that some of the harmonic terms of barometric pressure may be composed, to some extent, of terms borrowed from the series for tension. If we assume that because of our distance from the ocean, the vapour is more completely mixed with the air than, say, in England—or on any ocean littoral where the humidity of the lower air would vary between wide limits according to the direction of the wind—approaching more nearly, in consequence, to Dalton's final conditions, we may perhaps be justified in reducing Strachey's ratio to one-third. This would make the third and fourth harmonic terms in both pressure and vapour tension to be practically one and the same thing. Whence the resulting formula for the dry air alone would be, in inches,

$$\begin{aligned} P = (26{\cdot}136 - {\cdot}095) &+ {\cdot}0276 \sin (357°{\cdot}5 + n\,15°) \\ &+ {\cdot}0225 \sin (158°{\cdot}7 + n\,30°) \\ &- {\cdot}0045 \sin (252° \quad + n\,15°) \end{aligned}$$

The hourly deviations from the assumed mean pressure of dry air, at Kenilworth, computed by this formula are given at the end in the last column of Table II. They do not differ very much from the diurnal series obtained by subtracting one-third the tension at any hour from the pressure.

[1] See Note at end.

[2] The condensation of moisture at night, upon the dust particles suspended in the air and elsewhere, is given by Buchan as a contributing agent to the morning minimum of pressure. To my mind it is not an improvement upon his earlier views propounded in the *Ency. Brit.* Ninth Ed. See the "Challenger" *Report.*

The harmonic constants for this series of dry-air values are given in Table I. under the heading "Kenilworth, $p - \frac{t}{3}$." Of course it will be understood that these so-called hourly pressures of dry air are not supposed to be the same as they would be if the air were dry. They simply stand for the difference $p - \frac{t}{3}$ in a moderately damp air. The resulting curve is not much, if any, simpler than the ordinary barometric curve. The maximum and minimum come at nearly the same times; but the corresponding ranges are different in character. They are :—

	Barometric Pressure.	Pressure of Dry Air.
From midnight to first min.	·011 in.	·009 in.
First min. to first max.	·047 ,,	·037 ,,
First max. to second min.	·090 ,,	·088 ,,
Second min. to second max.	·055 ,,	·062 ,,

Such a method does not apply at extra-continental stations. At Hong-Kong, for example, the harmonic constants of pressure are altogether out of co-ordination with those of tension. It is true that in the second harmonic term the epoch remains fairly constant whatever proportion of the tension be deducted as representing the pressure of vapour; and that the amplitude decreases as the deduction is greater. Also that the amplitude of the first term increases with decrease of moisture, as, being a local thermal effect, and more or less of antagonistic phase to the first harmonic term of moisture, it ought to do. But the amplitudes of the third and fourth harmonic terms both increase. And therefore while the deduction of moisture must necessarily reduce the amplitude of every component, after the first, to begin with, yet evidently the harmonic waves of moisture are vibrating in opposition to those of pressure. So that the final outcome of the subtraction is a higher wave than before. It seems clear from this result that the actual pressure of aqueous vapour at such a station as Hong-Kong cannot have any simple relationship, outside the second harmonic term, to the tension observed at the surface of the earth. Nor is it likely that it should have in any similarly situated place.

At Allahabad the diurnal curves of some of the principal meteorological elements are similar to, though rather less simple than, those of Kenilworth. Hill, in discussing them, regarded the resemblance between the mean diurnal curves of pressure and vapour tension as quite fortuitous, "for it appears only in the annual averages. Moreover the morning minimum of vapour tension is equal to that of the afternoon, on the average of the year, while the barometric pressure is much lower in the afternoon than in the morning. The diurnal variations of vapour tension and atmospheric pressure are connected with each other, in so far as they are both effects of the diurnal inequality of temperature, but it is doubtful whether there is any other connection between them, except in an indirect way. At a dry station like Allahabad, where the range of the inequality of vapour tension is less than one-fourth of the range of pressure, it could never be supposed that the observed variation of the barometer is *caused* by the variation of the quantity of aqueous vapour in the air."[1]

[1] "Some Results of the Meteorological Observations taken at Allahabad, etc.," *Indian Meteorological Memoirs*, vol. 1, p. 335.

But, saving the last sentence, this is surely to take rather too extreme a view. There must be many powerful factors influencing the wet bulb that can scarcely affect the barometer, particularly in India. The truth

TABLE I.

	Barometric Pressure.			Vapour Tension.			"Dry Air" Pressure.			Temperature.
	Kenilworth.		Hong-Kong.	Kenilworth.		Hong-Kong.	Kenilworth.	Hong-Kong.		Kenilworth.
	May to Aug.	Nov. to Feb.	Year.	May to Aug.	Nov. to Feb.	Year.	Year.	$p-\frac{t}{3}$	$p-\frac{t}{4}$	Year.
V_1	354°50′	357°44′	356°54′	230°28′	346° 3′	251°58′	130°29′	6°13′	345°46′	348°48′	231° 3′
V_2	158 30	157 53	150 35	94 14	190 55	158 35	130 48	159 3	151 2	151 17	61 46
V_3	351 47	181 8	19 46	357 37	73 25	5 25	144 2		10 4	12 57	23 54
V_4	199 5	22 26	180 0	172 3	337 42	336 35	333 26		171 22	165 35	226 10
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	°
U_1	·0213	·0344	·0179	·0250	·0146	·0135	·0144	·0290	·0210	·0201	12·247
U_2	·0232	·0242	·0322	·0045	·0105	·0060	·0025	·0226	·0314	·0317	3·068
U_3	·0058	·0030	·0019	·0063	·0008	·0050	·0014		·0024	·0023	·741
U_4	·0011	·0011	·0010	·0021	·0042	·0006	·0012		·0014	·0013	·803
	Differences.			Differences.							
V_1	9°29′	179°15′		28°48′	206°57′						
V_2	165 0	244 5		202 41	41 16						
V_3	166 59	1 44		148 51	356 44						
V_4	10 53	210 0		348 0	158 7						
	in.	in.		in.	in.						
U_1	·0063	·0070		·0133	·0206						
U_2	·0012	·0004		·0057	·0063						
U_3	·0045	·0047		·0015	·0048						
U_4	·0011	·0012		·0028	·0036						

seems to be that the moisture of the atmosphere should be classified into two portions, the one barometric, the other more climatic having separate diurnal phases which precede or follow the barometric phases according

to the season. To illustrate this point, harmonic elements of tension and pressure, at Kenilworth, are computed for the two periods, May to August

TABLE II.—Deviation in Winter and Summer from the Annual Means.

Hour.	Vapour Tension.					Barometric Pressure.					Annual Deviation from the Normal.	
	Year. α.	May to Aug.	May to Aug. reduced β.	Differences. $\alpha-\beta$.	Nov. to Feb.	Nov. to Feb. reduced β'.	Differences. $\alpha-\beta'$.	Year. α.	May to Aug.	May to Aug. reduced β.	Differences. $\alpha-\beta$.	Nov. to Feb.	Nov. to Feb. reduced β'.	Differences. $\alpha-\beta'$.	Barometric Pressure.	Pressure of "Dry Air."
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
O.	0·274	0·193	0·270	+·004	0·349	0·278	−·004	26·143	26·247	26·141	+·002	26·044	26·143	·000	+·007	+·011
I.	·275	·192	·269	+·006	·352	·281	−·006	·139	·245	·139	·000	·040	·139	·000	+·003	+·007
II.	·274	·191	·268	+·006	·353	·282	−·008	·135	·242	·136	−·001	·036	·135	·000	−·001	+·003
III.	·271	·186	·263	+·008	·355	·284	−·013	·132	·239	·133	−·001	·036	·135	−·003	−·004	+·002
IV.	·269	·185	·262	+·007	·356	·285	−·016	·134	·238	·132	+·002	·041	·140	−·006	−·002	+·004
V.	·270	·183	·260	+·010	·357	·286	−·016	·141	·241	·135	+·006	·051	·150	−·009	+·005	+·011
VI.	·273	·182	·259	+·014	·371	·300	−·027	·153	·250	·144	+·009	·066	·165	−·012	+·017	+·021
VII.	·281	·185	·262	+·019	·382	·311	−·030	·165	·261	·155	+·010	·078	·177	−·012	+·029	+·031
VIII.	·294	·201	·278	+·016	·382	·311	−·017	·175	·274	·168	+·007	·083	·182	−·007	+·039	+·038
IX.	·303	·218	·295	+·008	·381	·310	−·007	·179	·283	·177	+·002	·081	·180	−·001	+·043	+·039
X.	·304	·227	·304	·000	·371	·300	+·004	·176	·284	·178	−·002	·075	·174	+·002	+·040	+·034
XI.	·303	·231	·308	−·005	·362	·291	+·012	·165	·274	·168	−·003	·065	·164	+·001	+·029	+·022
Noon	·299	·232	·309	−·010	·356	·285	+·014	·145	·253	·147	−·002	·047	·146	−·001	+·009	+·005
XIII.	·295	·231	·308	−·013	·348	·277	+·018	·124	·230	·124	·000	·030	·129	−·005	−·012	−·014
XIV.	·293	·229	·306	−·013	·345	·274	+·019	·105	·211	·105	·000	·008	·107	−·002	−·031	−·031
XV.	·288	·226	·303	−·015	·342	·271	+·017	·094	·204	·098	−·004	25·994	·093	+·001	−·042	−·044
XVI.	·286	·225	·302	−·016	·335	·264	+·022	·089	·203	·097	−·008	·983	·082	+·007	−·047	−·049
XVII.	·294	·238	·315	−·021	·335	·264	+·030	·091	·207	·101	−·010	·981	·080	+·011	−·045	−·046
XVIII.	·293	·226	·303	−·010	·340	·269	+·024	·100	·217	·111	−·011	·991	·090	+·010	−·036	−·037
XIX.	·290	·216	·293	−·003	·353	·282	+·008	·113	·228	·122	−·009	26·006	·105	+·008	−·023	−·024
XX.	·286	·208	·285	+·001	·355	·284	+·002	·127	·238	·132	−·005	·022	·121	+·006	−·009	−·009
XXI.	·280	·203	·280	·000	·352	·281	−·001	·137	·244	·138	−·001	·035	·134	+·003	+·001	+·003
XXII.	·278	·198	·275	+·003	·351	·280	−·002	·143	·248	·142	+·001	·045	·144	−·001	+·007	+·011
XXIII.	·276	·195	·272	+·004	·349	·278	−·002	·144	·249	·143	+·001	·048	·147	−·003	+·008	+·013
Mean .	0·285	0·208	0·285		0·356	0·285		26·136	26·242	26·136		26·037	26·136			

(winter) and November to February (summer), in Table I. These periods in particular being selected, because in the former the greater maximum

of the tension is in the afternoon, and in the latter it is in the morning. From a cursory glance we should conclude that there is not any close affinity between the two elements.

The matter, however, can be studied in another way. In Table II. will be found under the heading "Differences" the relative departures of the curves of vapour tension and barometric pressure, for May to August and November to February, from the annual curves. They are obtained by adding to each hourly value in the series for either summer or winter a proper constant number which shall make the respective means equal to the annual mean, and then finding the hourly differences. The process is given at length in the Table.

The resulting series are fairly regular. In the winter differences of vapour tension, the quantities are positive between XXII. and IX., and negative from X. to XXI., the exact reverse being the case in summer. That is, the winter and summer differences are opposite in phase relatively to the mean.

The same law holds for the barometric differences. The variation is less, being from one-half to one-third, in absolute amount—agreeing again as closely as we could expect with our provisional assumption that the pressure of the independent atmosphere of vapour is one-third the observed tension—and is rather more irregular; but it is important that their affections are in the same direction, and their phases very nearly at the same times. This fact suggests something more than an accidental coincidence in the diurnal curves. And it is the more noteworthy because the monthly vapour tension is least when the barometric pressure is greatest.

If we resolve the curves of winter and summer differences into their harmonic elements (Table I.), some additional light may be thrown upon the significance of this hypothetical affinity. The most prominent feature of the resolution is the relatively trivial second harmonic term of pressure differences, particularly in summer—of course largely a necessary consequence of the known imperturbability of the second harmonic term of pressure throughout the year. Next the equality of magnitude of the other terms summer and winter. But at first sight it might appear that the comparative harmonic constants of pressure and tension differences destroy the semblance of concordance which Table II., in conjunction with the mean diurnal curves of pressure, and tension, for the year, might be supposed to imply. Fortunately, though, it is not so. The following numbers show the angular advance of the epoch from winter to summer in each case:—

	Pressure.	Tension.	Time Diff.
V_1	169° 46′	178° 9′	+ 34 min.
V_2	79 5	198 35	+239 ,,
V_3	194 45	207 53	+ 18 ,,
V_4	199 7	170 7	− 29 ,,

Thus the advance is not far from two right angles in every case excepting one. The column of time differences indicates the length of time during which the tension epoch continued to advance in excess of the pressure epoch. Or, for example, to put it in a different way, while the pressure epoch of the first harmonic term is 11h. 19m. earlier in winter than in summer, that of the tension is 11h. 53m. earlier. Only in the fourth

harmonic term is the pressure advance the greater; and saving only the second term, the difference scarcely exceeds half an hour. It appears from this result that such variation as there is in the tension, disturbs only the first, third, and fourth harmonic terms of pressure, and that although the second term of pressure may include a quota of vapour, yet its final magnitude is independent of the composition of the wave: that is, if there be less vapour there will be more dry air, and *vice versa*.

By something short of complete confidence, then, we may judge from both statistical and analytical investigation, that there is a very intimate relationship between the diurnal variations of pressure and tension. A reference to Table I. will explain with some clearness the reason for certain apparent exceptions to the rule. The affinity between pressure and tension, such as it is, is most marked in summer; in winter the most important term is essentially thermal. In fact there is only a difference of two minutes of time between the epochs of the first harmonic terms of tension and mean temperature. The explanation of this fact is probably to be found in the relative humidities of winter and summer. For the more nearly the air approaches the point of saturation the more nearly must the curve of vapour tension conform to that of the temperature. No matter how influential the barometer may be, its ascendency ends entirely at the dew point. So long as the air is saturated, a fall of temperature means the condensation of moisture, and a rise of temperature in the presence of water means evaporation, whether the barometer be rising or falling. And probably these are the circumstances which give the diurnal curves of tension, in particular months, those deviations from the annual mean which made Hill regard the annual coincidence between the mean diurnal curves of tension and pressure as accidental.

It seems necessary to interpret some of the resemblances between the harmonic constants of these curves in a moderately dry air before we are in a position to judge, even at random, how much of the semidiurnal oscillation of the barometer is thermal and how much mechanical, or, indeed, whether it be each or either. It is perhaps a reasonable conclusion from the evidence so far led, as also from facts remarked upon in a former paper, that so much of the general pressure curve at Kenilworth as is represented by the first harmonic term is to a large extent thermal, while the rest is principally due to mechanical movement. The explanation of the semidiurnal oscillation of the barometer, therefore, really depends upon the amount of success we may meet with in determining the origin of the second harmonic term of pressure for the diurnal series.

Here, however, I venture to quote at length Professor Bigelow, who offers the following explanation of the two known types of diurnal periods, one the single oscillation at high altitudes, the other the semidiurnal oscillation at lower levels:—

> Let us illustrate the formation of the double diurnal period at the earth's surface and the single period in the cumulus level by considering the behavior of the absolute humidity, that is the number of grams of water vapor per cubic centimeter. The first diurnal effect of the radiation from the earth is to raise the vapor content of the atmosphere from the low level occupied by it at night to a higher level during midday. This absorbing screen of water vapor, visible or not, rises and falls once daily through 1000 or 2000 meters, taken as a whole. While the warm air rises by convection from the surface to the level

of 1500 meters, the vapor rises with it and endeavors to saturate the unit volumes of the higher strata at the prevailing lower temperatures, the depleted lower volumes being *partially filled up again by fresh evaporation* from the water and land surfaces. . . . There is a decrease of actual temperature with the elevation, and therefore the saturated unit-volume content decreases. The vapor sheet rises to higher levels, and this together with the fresh supply by evaporation from the surface, can refill the depleted volume again, especially during the forenoon hours. After the noon hour the continued increase of temperature gives rise to larger vapor capacity per unit-volume. . . . But while the rising vapor sheet keeps the upper volumes filled, the lower, which are drained by the ascension of the water vapor, cannot be supplied by evaporation at the surface at a sufficiently rapid rate to keep them full, because the prevailing surface moisture has been taken up at an earlier hour. The same remarks are true for the relative humidities. The result is that the upper volumes are always full, or relatively full, and have an increasing actual content up to the early afternoon, about 2 p.m., so that the diurnal curve at some distance above the ground has a single maximum and minimum as observed. On the other hand, while the 10 a.m. surface volumes are kept filled, or relatively filled, they are actually depleted in the afternoon and are not replenished by evaporation up to the original relative humidity of the morning, and therefore the curve shows a depression in the early afternoon, and is doubly periodic. The second maximum at the surface is due to a reversal of this process as the vapor settles back slowly to the ground during the afternoon and night. The additional lag of the evening maximum, being four hours in the evening to about 10 p.m., is due to the slow cooling of the ground after sunset, which continues to be a source of heat for several hours, and the slow conductivity of the heated atmosphere, which retains its heat even longer than the ground after the sun has set.

And the distinguished meteorologist adds—

"This theory, if pursued into quantitative details, will evidently account for the entire series of observed phenomena." Moreover, "analyzing the diurnal barometric pressure by volume contents we see that with the heating of the lower strata the denser air of night is replaced by contents of lower density after mid-day; taking into account the lag, the lower volumes are depleted and the upper are filled relatively, thus producing the two types of periods. . . . The later diurnal lag in the evening to 10 o'clock is a function of the cooling of the lower atmosphere by convection and radiation, and the settling back of the vapor sheet to the surface of the ground. The details of this phenomenon . . . can all be shown to be in accord with this view."[1]

But is it so clear that this theory will account for everything? There is, for example, the difficulty that at Kimberley, in July, when not a cloud obscures the sky, nor any dew is deposited for weeks together, the second maximum of vapour tension occurs just about sunset, and is much greater than the first; whereas in the more cloudy summer it is inappreciable. Failing condensation in either the upper air or on the earth's surface, it is not easy to see what will cause the vapour to settle back slowly to the ground. On the contrary, since both the higher and lower levels of the atmosphere are colder at night than the middle reaches, particularly in the winter, it would seem that the vapour should show a

[1] From a paper read before the American Association in Dec. 1902, printed in the *Monthly Weather Review* for Dec. 1902 (published Feb. 19, 1903).

disposition to remain in the latter, and even to slightly tend towards it by diffusion from above and below; and hence that the absolute humidity near the ground should decrease. At Kimberley, indeed, it does decrease, for some hours after sunset, without necessarily any condensation of moisture, either in the form of dew or cloud. It is easy enough to see that the ascending convection currents of warm air will raise the vapour planes to greater heights by day; it is easy to see that the same planes must sink again at night.[1] Excepting only the possible case of the uppermost strata, they do not, nevertheless, sink to the same level at night as that from which they rose in the morning. If they did the dews at night over the land would be equal to the evaporation by day. But nothing is more certain than that in conditions similar to those of Kimberley, evaporation from land and water is continuous often day and night for weeks at a stretch, and that rain alone is competent to restore the depleted moisture. There are not any return convection currents at night: their ascent is simply checked. Therefore the vapour from the middle reaches of the air could only sink, if it sink at all, by the slow process of diffusion—and how slow that can be may be realised from certain of Lamont's experiments which did *not* controvert Dalton's results. For this reason, apparently, Professor Bigelow's explanation does not account for more than a half of the observed facts at the most.

Now I have been able to show that the winds of Kimberley, in the course of the day, veer with the sun; and in such a way that the normal mean direction at any hour is tangent to an imaginary spiral curling outwards from an origin of greatest temperature, about 45° behind the sub-solar point, and inwards to an area some 100° in front of the same point. This rule holds winter and summer, whether the months be hot or cold, dry or damp. Whence the claim has been made that if we develop the east and west exchanges of air in this system we may very likely pick up ideas as to the cause of the pressure oscillation. Of course the diurnal veering of the vane is no new fact, though possibly no other station shows it so simply, so plainly, and so free from perturbation, as Kenilworth does. But recently it has acquired a new significance as the outcome of an elaborate analysis by Hann of some anemometer records on mountain peaks of considerable altitudes. It appears that the diurnal veering of the vane may be detected up to at least an altitude of 13,000 feet, and that barometric affinities are present in the east and west components of wind-movement. Thus the phenomenon is general.

The following process seems to be suggested by the facts in hand: First, and most important, by the outward flow of the lower air from the area of greatest heat,[2] with the tendency to both the establishment of a minimum over the heated area and an accumulation of air over, or adjacent to the dark hemisphere. Next the imposition upon this of an

[1] It is found that "as night approaches the humidity at the altitude of 1000 metres diminishes, while at the earth's surface it increases. This agrees with the evidence furnished by the cumulus clouds which form during the day between 1000 and 2000 metres altitude, and which disappears at night, thus visibly indicating an increase of humidity by day and a decrease by night" (H. H. Clayton in the Blue Hill *Observations* for 1896, p. 105. Repeated also by A. L. Rotch in *Sounding the Ocean of Air*, p. 153).

[2] In "anti-convection" currents. See Herschel's *Meteorology*, 2nd ed., p. 73; F. Chambers, "Winds of Kurrachee," *Indian Met. Memoirs*, vol. 1, p. 265; "Wind and Barometric Pressure at Bombay," *Phil. Trans.* 163, 1873, p. 8.

augmented pressure near the area where the temperature is rising most rapidly, say about VIII., and generated directly by such rise from the rapid increase of tension due to local heating. Also the imposition of a diminished pressure near the area where temperature is falling most rapidly, say about XVI., due to the rapid decrease of tension set up by local cooling. Again, while there may be actually more air over the dark hemisphere, it is not, necessarily, shown by the barometer; *i.e.* the barometer does not rise, because the tension is reduced through the falling temperature near the ground. Something more is required here, however, than a mere excuse for the barometer not rising. We are called upon to explain even why it falls. And there is no doubt that the morning minimum is the most elusive of all the barometric phases. It seems probable that since moist air is a good absorber and a good radiator of heat, the rate of cooling of the total mass of air will depend directly upon the total quantity of vapour present, and will be integrally greatest after midnight.

So far this applies principally to continental areas. The most important variation over the ocean would be due to the larger absorption and radiation of heat by the total mass of air, in consequence of the contained moisture; and less local variation in the temperature of the floor. The afternoon minimum would hence be less, and the morning minimum more pronounced. On ocean littorals, and in places neither strictly oceanic nor strictly continental, there will be great and complicated variation because of the interaction of the two main classes of phenomena.

Such an explanation as this, though in a sense experimental, requires that the second harmonic term of pressure should be pretty general, and the first as much local. And so far they conform to the facts established by Hann's researches. The question will arise, of course, whether this scheme of pressure oscillation accounts in any degree for the sunset maximum of vapour tension. To that it may be promptly admitted that it is beyond the power of any meteorologist in the present state of science to explain completely any such phenomenon. But this may be suggested, *meo periculo*. The vapour rises to higher levels in convection currents and by a process something akin to percolation as the general temperature of the air increases during the morning; its place being supplied more or less completely by further evaporation from land and water; it is also carried outwards and upwards in the outward and upward expansion of the air under the sun's rays, and, moreover, outwards by the spiral outflow of air from the area of greatest temperature. The outflow along the ground set up by these causes will continue so long as the temperature gradient is not steep in proportion to the outward forces. But where the gradient is steep, near the time of sunset (and particularly in winter), the capacity of the more easterly of two adjacent masses of air for vapour will be so much the lesser that the outflow may be arrested, and even set back upon itself. Also the upward convection currents are now checked. Thus not only does its own vapour not now rise, but neither does the access it receives from the spiral outflow of air.

The following numbers show the deviations of the dew point at special hours, on a typical clear and a typical cloudy day, from the mean, after weighting them according to seasonal distribution :—

Hours.	Clear Days. From mean.	Clear Days. From min.	Cloudy Days. From mean.	Cloudy Days. From min.
	°	°	°	°
V.	−1·7	0·0	−1·3	0·0
X.	+2·3	+4·0	+1·2	+2·5
XVI.	+0·5	+2·2	−0·6	+0·7
XVII.	+1·1	+2·8	+0·1	+1·4
XXIII.	−0·8	+0·9	−0·9	+0·4

The corresponding numbers for the barometer are :—

Hours.	Clear Days. From mean.	Clear Days. From min.	Cloudy Days. From mean.	Cloudy Days. From min.
III.	−·008 in.	+·039 in.	−·001 in.	+·044 in.
IX.	+·042	+·089	+·042	+·087
XVI.	−·047	·000	−·045	·000
XXIII.	+·002	+·049	+·014	+·059

It appears from a consideration of the shapes alone of the annual curves from which these turning-points are taken, that the only difference between the dew points under clear and under cloudy skies is the much deeper night minimum of the former; while both the night maximum and the night minimum of the barometer are lower when the sky is clear than when it is cloudy. It is possible, however, that some of this result may be due to the medley of the various months.

For a single month, taking July as being the least cloudy month of the year, the comparison is much more definite. The deviations of the dew point are :—

Hours.	Clear Days. From mean.	Clear Days. From min.	Cloudy Days. From mean.	Cloudy Days. From min.
	°	°	°	°
VI.	−5·1	0·0	−3·1	0·0
XIII.	+3·7	+8·8	+2·0	+5·1
XVI.	+3·2	+8·3	+1·3	+4·4
XVII.	+5·0	+10·1	+2·3	+5·4
XXIII.	−2·4	+2·7	1·6	+1·5

The corresponding deviations for the barometer are :—

Hours.	Clear Days. From mean.	Clear Days. From min.	Cloudy Days. From mean.	Cloudy Days. From min.
IV.	+·001 in.	+·034 in.	−·005 in.	+·036 in.
X.	+·049	+·082	+·041	+·082
XVI.	−·033	·000	−·041	·000
XXIII.	+·007	+·040	+·009	+·050

As before, the night minimum of dew point is considerably lower when the sky is clear than when it is cloudy; while the range from the morning maximum to the afternoon minimum is fairly constant in either case. But most important of all, the abrupt leap from the afternoon minimum to the afternoon maximum under clear skies is nearly double the other. Comparing corresponding pressures, we see that the daylight portions of the curves are identical under both clear and cloudy skies; the night minimum falls rather the lower under clear skies, and the night maximum remains appreciably lower. That is to say, when the vapour is massed the more at sunset, the following rise of pressure to the XXIII. maximum is less, and *vice versa;* the inference being, according to the above attempt at theory, that some of the vapour under cloudy skies (when of course the temperature gradient is gentle) is carried forward to the account of the barometric pressure.

NOTE.—De Luc, ten years before Dalton, made some very acute remarks in the *Philosophical Transactions* for 1792 upon the phenomena of evaporation. He mentions that if the evaporating water be warmer than the space receiving it, more water will evaporate than when there is an equal temperature in both, and the reverse if the vapour be cooler. Vapour is generally greater as the temperature increases. "The product of evaporation is always of the same nature, namely an expansible fluid, which either alone or mixed with air, affects the manometer by pressure, and the hygrometer by moisture, without any difference arising from the presence or absence of air; at least without any hitherto perceived."

It had been known for some time before De Luc that water would evaporate in a vacuum. But it was also supposed that air was a chemical solvent of water.[1] Bishop Watson in *Chemical Essays*, vol. 3, p. 109, made a very interesting summary of the state of our knowledge of this subject up to 1781:—"It is certain that heat will evaporate water, and great degrees of it may probably evaporate it faster *in vacuo* than in the open air, inasmuch as the pressure of the air may tend to obstruct the action of the heat in converting the water into vapour. . . . But though heat may be one cause of the evaporation of water, the attraction between air and water, upon whatever principle it depends, may be another."[2]

DISCUSSION.

Mr. W. H. DINES said that he thought the Society was much indebted to Mr. Sutton for the information he had tabulated and worked up upon a very puzzling subject, for such the double daily oscillation of the barometer undoubtedly was.

He considered that the barometer was a strict and accurate measurer, as indeed its name implied, of the mass of material above it, and, apart from electrical action, it gave an exact measure of the total mass, whether it were in the form of air, water vapour, or solid water particles. In the last instance, however, it must be assumed that the velocity with which the water, in the form of raindrops, was falling was not appreciably altering. He was sorry to see a very old fallacy revived as a suggested cause of the morning maximum. An increase of the volume of the air, either by heat or by the addition of water vapour, could not possibly produce more than a momentary increase of pressure. The air was entirely free and unconfined above, and would give way immediately. It was as impossible to produce an increase of pressure in such a way as it would be to blow up a bicycle tyre that was full of punctures. Moreover, even were it possible, the inertia of the mercury column was the same as the inertia of a vertical column of air of the same section, and if the inertia of the air column were great enough to allow this change of pressure to occur, equally the inertia of the mercury would be so great that it could not record the change.

He thought the most hopeful explanation was that suggested by Dr. Hann, namely, that the natural period of oscillation of the atmosphere as a whole was about twelve hours. With any oscillating body, a very trifling force was sufficient, provided it were properly timed, to set up an oscillation,—a child swinging, for

[1] *E.g.*, Dobson on "Evaporation," *Phil. Trans.*, 1777.

[2] The ancient philosophers had some glimmerings of the process of evaporation. See, for example, "The Life of Zeno" in *Diogenes Laertius* (C. D. Yonge), and "Epicurus to Pythocles" in the same. Compare also Lucretius, *De Rerum Nat.*, Lib. 1; and Vitruvius, *Architecture*, Bk. 8.

example,—and in this case the disturbing cause could be found in the daily change of temperature. The harmonic analysis of the temperature showed that there was a small but decided term, with a twelve-hour period, and, granted that the atmospheric oscillation had a period of nearly twelve hours, this would suffice. The calculation of the period was rendered very difficult, perhaps insoluble at present, by the modifications produced by the rotation of the earth and by friction.

Dr. W. N. SHAW said he hesitated to speak upon so difficult a question as the diurnal variation of the barometer. He had doubts about the statement that the height of the barometer depended exclusively upon the weight of the column of air immediately above it. Air was an elastic body, and if a slow pulsation could be transmitted like a sound wave, a corresponding variation of atmospheric pressure would be indicated. In estimating the effect of disturbing causes upon the atmosphere we have to recollect that the velocity of the air at the equator is something like 1000 miles per hour, and the elastic properties of a rapidly moving system are different from those of the same system at rest. If a closed chain is made to spin with great rapidity in its own plane so as to form a kind of wheel, link following link, when placed on its rim on the table it will roll along the table and rebound from the wall as though it was a hard elastic body. From this it will be seen how difficult it is to explain atmospheric phenomena without taking into account the quasi-rigidity due to rapidity of motion even in a mass of moving air.

In order to get some clear ideas upon this subject, he had made a model consisting of a cardboard disc from which hung twenty-four small iron bobs by short strings, representing air particles, and placed the disc on a Maxwell dynamical top. He believed that the bobs could be thus made to move under conditions dynamically similar to those of air particles near the equator.

The model was originally made with the object of ascertaining whether, when a disturbance was imposed upon successive particles as they passed *one position* in their rotation, the whole set remained similarly and equally displaced, or whether, or under what conditions, there was a redistribution of displacement producing an effect analogous to the double maximum of the diurnal variation of the barometer. So far the model had not been much more than an entertaining toy, but it was sufficient to show that the subject presented difficulties in statics and dynamics so great as to render it almost impossible of approach from the point of view of attributing local effects to purely local causes. Therefore, when he read of computations of alterations of temperature in particular spots and consequent effects upon barometric pressure in the same places, he found them extremely difficult to follow. The subject required some more generalised method of treatment.

Mr. R. H. CURTIS, in a note to the Secretary, said :—"There can be no doubt that in temperature we have the *primum mobile* of the phenomenon of the diurnal range of barometric pressure; and the different characters which the diurnal curve exhibits with different types of weather seems to show pretty clearly that it is the diurnal *range* of temperature, rather than the actual amount of temperature, which determines the amplitude and character of the diurnal barometric oscillations. At the same time, however, it is also fairly certain that the vapour in the air plays an important part in bringing about the movement of the barometer, although precisely in what way it acts it is not easy to determine. But the fact referred to by the author in the opening paragraph of his paper, that the vertical distribution of vapour through the atmosphere is by no means uniform, whilst there are at present no means readily available of ascertaining how, or to what extent, it varies during the day, is sufficient to make the difficulty of gauging its effect clear. The assumption that the distribution of vapour throughout the atmosphere is more uniform at Kimberley than over

England does not appear to rest upon any observational basis; and bearing in mind the fact that at times great variations of temperature occur in the course of twenty-four hours in South Africa, I question whether it is altogether justified, in spite of the greater distance of Kimberley from the sea. But in the face of this uncertainty it appears to be very risky to assume, as the author has done, that he is justified in changing the ratio adopted by Strachey, which is itself hypothetical, from one-fourth to one-third. But it appears to me to be fundamentally wrong to approach the discussion of the phenomenon of the diurnal variation of pressure upon the basis of general *mean* results. The curve yielded by the means for July, for say Kew, is quite unlike that obtained from the means for the same place for January; and the mean values for the year yield a curve which does not properly express the phenomenon as observed at any special part of the year, and therefore represents no real physical fact. But, on the other hand, if values are used for days on which certain features of the element of temperature were similar, whether those days are in summer or winter, the curves they yield will always more or less resemble each other; and therefore, if means are used, they should be for days when the conditions as regards certain elements, the effect of which upon the diurnal range of pressure it is desired to test, are similar. For certain English stations for which an attempt had been made to find what was the relation of the diurnal curve of vapour tension to that of the total pressure as shown by the barometer, I found that the minimum of vapour tension occurred in the morning a little later than the minimum of pressure; but the maximum of vapour tension coincided, as regards time, very closely with the afternoon minimum of pressure. This, however, was for days of average range of temperature; and the relation between the two curves underwent considerable modifications, very suggestive in themselves, when the conditions as regards temperature became modified."

Curious Electrical Phenomenon.—In case it may prove of interest to some Fellows of the Society, I beg to relate an unusual occurrence which took place here early on the morning of June 14, 1903. At about 3.30 a.m. I was awakened by a report like the firing of a cannon, followed by a more or less long whizzing noise, with a second report a second or two after the first one. At first I thought a cannon must have been fired somewhere not very far off, only the sound seemed to be up in the air. Making up my mind to try and find out in the morning what caused the noise, I tried to go to sleep again. I had hardly turned over when a terrific explosion took place, as it appeared to me, just over the house I am living in. It was a sudden, terrifying report followed by a tearing, rending noise, giving one the idea that some large wooden structure was being torn asunder by some great force, and ending with a peculiar crackling sound.

My first idea was that the dynamite magazine here had exploded, and I jumped out of bed immediately to look around outside. I saw at once, by former experience, that the magazine had not exploded. My next idea was that it must have been a meteor, more especially as both I and another member of my family were sure that we had heard some hard particles falling on the iron roof of the house. But on examination in the morning, just after sunrise, all round the house and on the roof, no meteoric particles were to be found. I then came to the conclusion that the explosion must have been caused by some electrical disturbance or phenomenon; and on discussing the matter with the electrical engineer on this mine, he agreed there was no other way of accounting for it, stating at the same time that the electrical conditions of the atmosphere here were most unusual. As far as I have been able to ascertain at

present, the explosion was heard at places 10 or 12 miles apart, and was noticed by about twenty people. There are miles of country here without a house, so that, taking that into consideration, it was heard by quite a number of persons. The night was perfectly calm and clear, without a cloud in the sky, and there was brilliant moonlight. I served through the siege of Kimberley, and so heard many 100-pounder shells explode, but the noise they made was small compared to the explosion I have been writing about.

It would be interesting to learn what records you have of similar occurrences in other parts of the world.—H. BOURHILL, Transvaal and Delagoa Bay Collieries, Witbank, Transvaal.

Death by Lightning.—The question whether, when a workman is killed by lightning during the course of his employment, his representatives can obtain compensation under the Act of 1897, recently came before Judge Bradbury at the Liverpool County Court. It appeared that on August 14 in the present year a bricklayer, whose death gave rise to the action, was at work with his mate on a scaffold. The scaffold was 23 ft. in height. At the first hearing a doubt arose whether the fact that the deceased was working on a scaffold 23 ft. from the ground made an appreciable increase in the risk of his employment, as compared with working on the ground, and his Honour adjourned the case for expert evidence to be called on that point. At a subsequent hearing Dr. C. C. Garrard, head of the testing department at Ferranti's works, and Mr. J. M. Faulkner, of Manchester, both gave evidence to the effect that the fact of his being on the scaffold had sensibly increased the risk. His Honour held that inasmuch as the position in which the deceased was working was a dangerous position, he found as a fact that the accident arose out of, and in the course of, the employment. He therefore gave judgment for the plaintiff, but expressed the wish that the matter might be taken to the High Court for final adjudication.

This is one of the nicest questions in connection with the Workmen's Compensation Acts which has yet arisen. As our readers are well aware, compensation is payable where the accident arises "out of, and in the course of, employment." That the death by lightning was caused "in the course of" the employment there can be no doubt, but how can it be said to have arisen "out of" the employment in the strict sense of the term? The Act is intended to insure workmen against any accident which is the result of any risk to which they may be exposed in the course of the particular employment. Thus if a brick were to fall on a bricklayer's head, or if he were to fall from the scaffold, his employers would clearly be liable. But every one who is exposed to the weather during a thunderstorm is liable to injury by lightning. How, therefore, can it be said that this particular accident arose out of the employment? It must be assumed that, in coming to his conclusion, the learned judge was influenced by the opinion of the witnesses, who stated that the fact of the deceased being on a scaffold 23 ft. high exposed him to a somewhat greater risk. We shall await with interest the review of this decision in a higher court, although it is quite possible that the Judges may say that the question was one of fact for the County Court Judge.—*Electrical Review*, December 18, 1903.

THE GREAT DUST-FALL OF FEBRUARY 1903, AND ITS ORIGIN.

By HUGH ROBERT MILL, D.Sc., and R. G. K. LEMPFERT, M.A.

[Read November 18, 1903.]

Remarkable falls of dust from the atmosphere were observed in various parts of Europe in the spring of the three consecutive years 1901, 1902, 1903, and have formed the subject of investigation in several countries. The great dust-fall of March 1901 was discussed in detail by Professors Hellmann and Meinardus; the fall of January 1902, which was less widespread in its distribution, was described by one of us before this Society; and the third, which occurred in February 1903, has been the occasion of several papers in different countries. Of these, the most comprehensive, which appeared after the greater part of our work had been done, is by Dr. E. Herrmann of Hamburg, and is published in the *Annalen der Hydrographie* for October and November 1903. We have approached the subject from a point of view which differs in some respects from that of Dr. Herrmann, and have concerned ourselves mainly with the problem of the relation between the fall of dust and the larger motions of the atmosphere.

The distribution of the dust in the British Isles has been ascertained with a fair degree of completeness by the co-operation of the Meteorological Office, the Royal Meteorological Society, the British Rainfall Organisation, and a large number of other observers in all parts of the country. The letters and references in newspapers which have been utilised for this purpose number more than 400. A list of places at which dust was noticed in the British Isles will be found in the Appendix (p. 79). The places where the phenomenon occurred on February 21 or 22 are shown upon the map, Fig. 1, of the British Isles by means of dots; and in order to make the distribution appeal more directly to the eye, the whole of the land surface over the southern half of England and Wales within 10 miles of a point where the dust-fall was observed is shaded (Fig. 1). It thus appears plain that the dust fell over nearly all parts of England and Wales to the south of a line drawn from Anglesey through Wrexham and Northampton to Ipswich. While dust was probably precipitated in some degree over the whole area which is shaded in Fig. 1, the difficulty of detecting a light-coloured foreign dust in the constant fall of locally produced soot accounts for the absence of reports from large towns. The intensity of the fall undoubtedly varied much from place to place, and the number of definite statements made by experienced observers who looked carefully for the dust convinces us that there was no perceptible fall in the areas in Cornwall, Devon, Somerset, and Wiltshire left white in Fig. 1. The area over which dust fell comparatively thickly in England and Wales was certainly not less than 20,000 square miles, or ten times greater than in 1902. Although there are no data available for an accurate estimate of the amount of air-borne dust which fell, the total quantity of deposit in England is not likely to have been less than 10,000,000 tons.

For particulars as to the Continental falls we are indebted to the Meteorological Institutes of Belgium, Holland, and Germany, to Captain Chaves of the Azores, as well as to private correspondents and press notices. The distribution of the deposit over Europe is shown in Fig. 4. A detailed list of the places in which the phenomenon was observed will

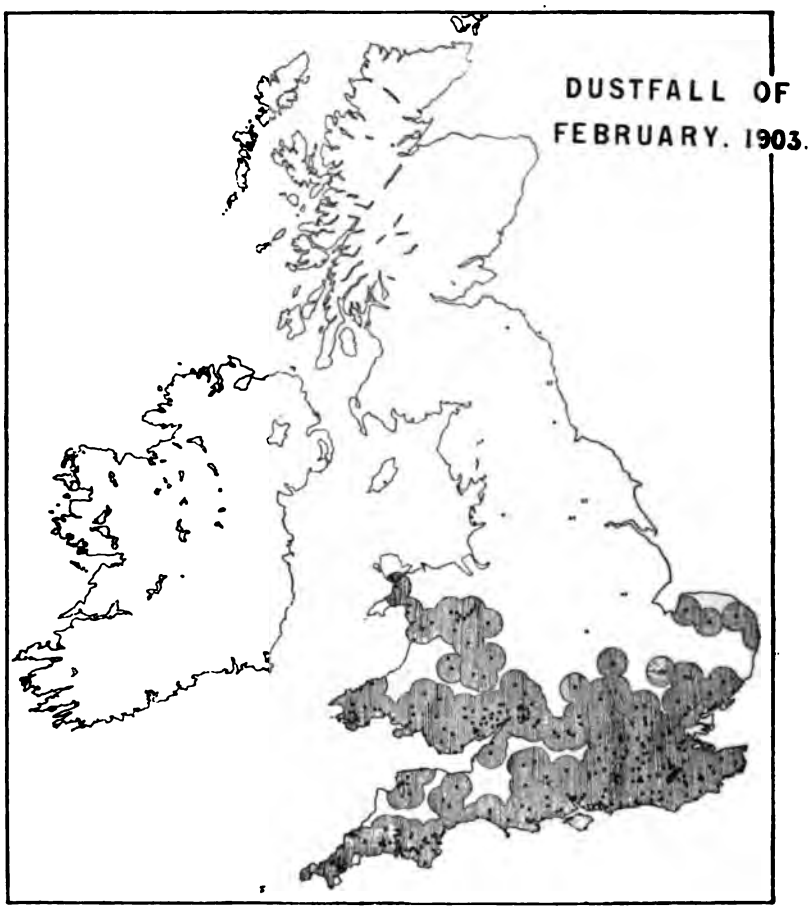


FIG. 1.

be found in Dr. Herrmann's paper; as his information is, in the main, derived from the same sources as our own, we have not thought it necessary to give all the details *in extenso*.

The dust usually attracted attention either in the form of a dense yellow haze like a London fog or as a reddish-yellow powder lying thickly on trees or roofs. In some instances it fell as a dry powder, in others it was noticed in the form of drops of muddy rain; again in others the circumstance which struck the observer was the soapy appearance of the water in a rain gauge, a water-butt, or, in one case at least, in a leet carrying the water-supply of a town. The fall was often accom

panied by temperatures considerably above the average, and by remarkably low relative humidities; at Uccle near Brussels, for example, with a dry-bulb temperature of 58° the relative humidity was only 32 per cent of saturation.

From the list in the Appendix it appears that the 22nd was the date on which the dust-fall was most widely observed, although it was un-

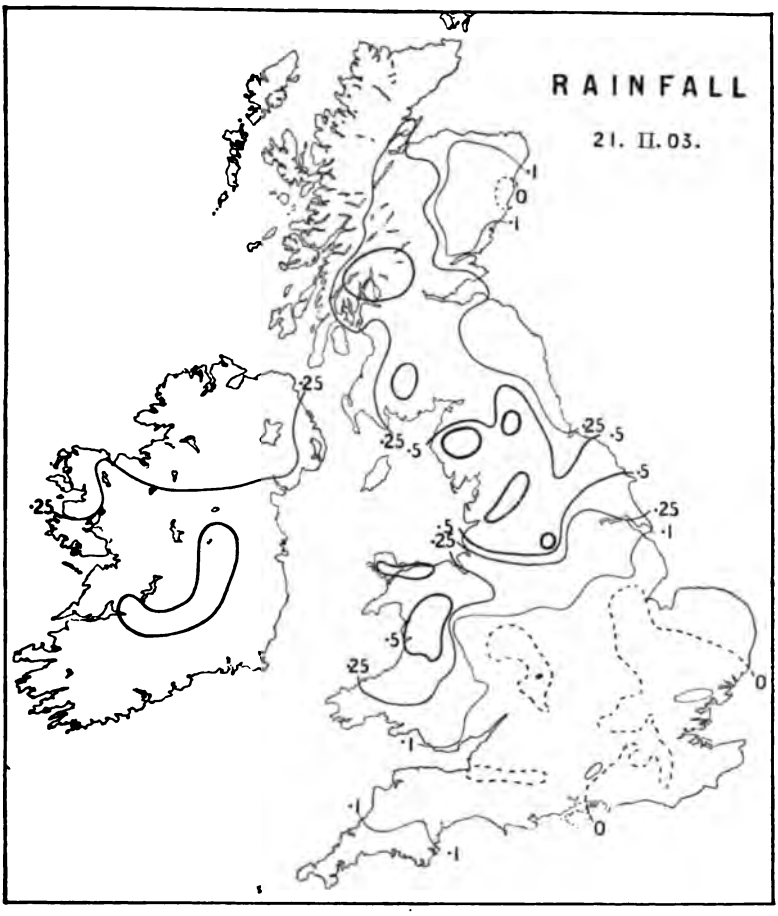


FIG. 2.

doubtedly experienced in several places on the 21st. The reports of dust on or before the 20th are few in number, and may perhaps be explained by errors in date consequent on the observer writing from memory after the lapse of some days. In the case of dates after the 22nd it seems not unlikely that some of the dust remained in the air and settled down gradually, but there appears to be reason for supposing that a distinct renewal of the fall, though on a much smaller scale, occurred between the 25th and 27th. On the Continent copious dust-falls occurred in Belgium, Holland, and Western Germany during the afternoon and

evening of the 21st, and continued at intervals during the 22nd and 23rd. In Austria and the greater part of Germany the main fall occurred on the 22nd and 23rd, though in a few instances we find the 21st mentioned.

Rainfall maps were prepared for February 21st and 22nd, and it will be noticed from Fig. 2 that no measurable rain fell in the south-east of England from 9 a.m. on the 21st to 9 a.m. on the 22nd, and less than ·10 in. fell in

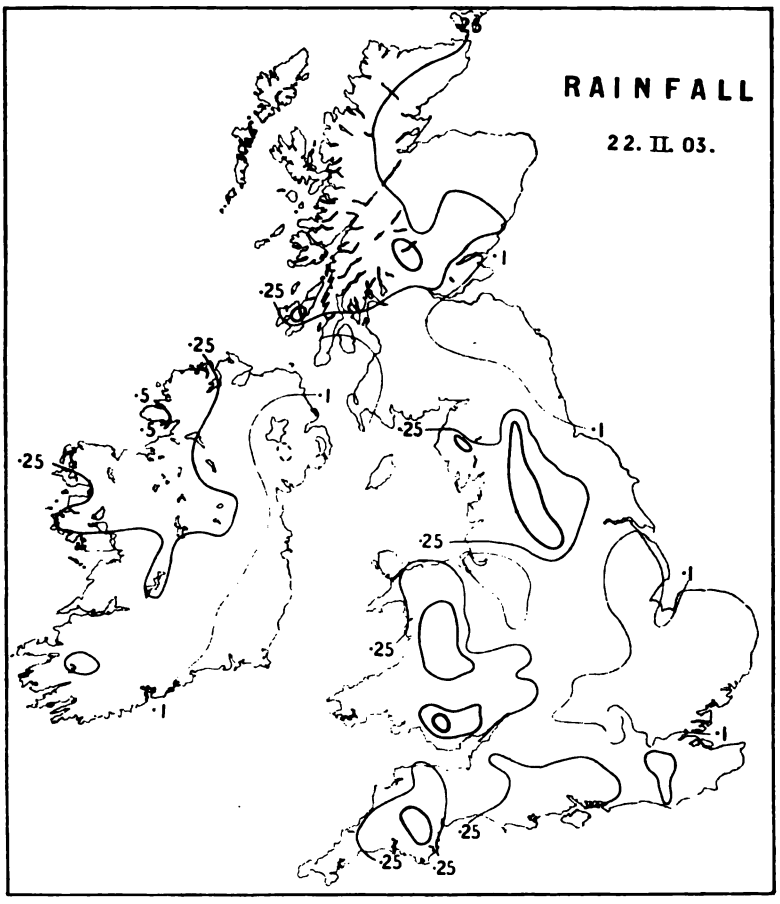


FIG. 3.

the south-west. This rainfall day was characterised by high temperature and low humidity, and it was during it that the falls of dry dust were observed, the high winds serving to mix the air-borne dust as it fell with grosser particles from neighbouring sands, fields, or roads. Fig. 3 shows the distribution of rainfall for the day from 9 a.m. on the 22nd to 9 a.m. on the 23rd. It shows that the Eastern counties, part of the Midlands, and the Cheshire plain had less than ·10 in. of rain, while the greater part of the west of England had more than ·25 in. This was the rain which was so largely discoloured with the dust washed out of the air as it fell.

While the list of observations summarises the facts as to the distribution and general character of the dust-fall, the description of the appearances as they struck observers who were not specially on the watch for unusual meteorological phenomena can best be given in their own words. The general phenomena were similar in all parts of the

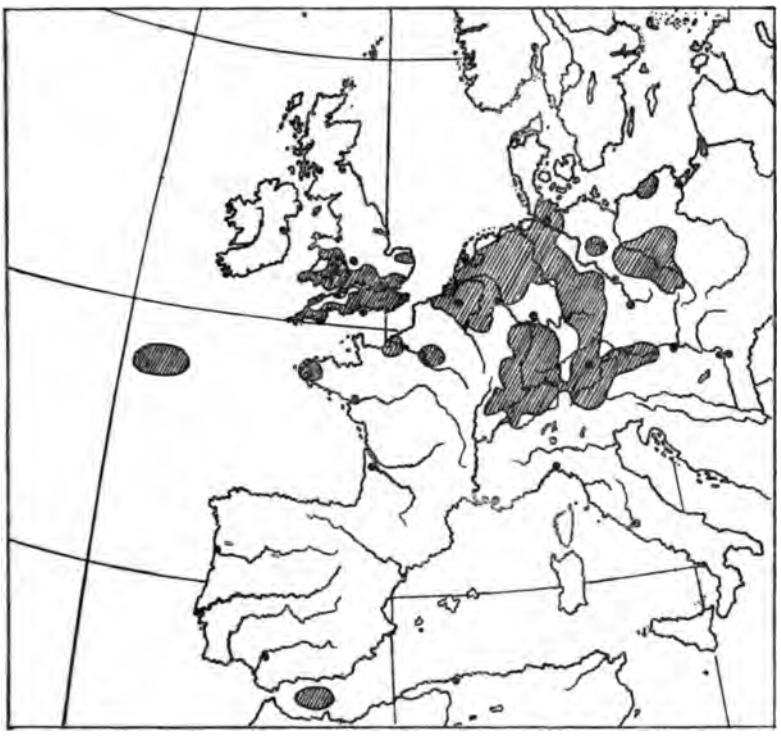


FIG. 4.—Distribution of Dust-fall over Europe.

country, but the amounts of dust that fell varied considerably; and in some places it fell dry, in some only mixed with rain. It has been necessary to select a few of the hundreds of descriptions as representative of the whole, and these are quoted below. It is clear from the notes of observers that the fall was not only much more widespread, but also much more intense than that of January 1902:—

FINDON, near WORTHING.—Just a line respecting the fall of the dust on February 23. I see by the *Morning Post* on Monday last you wish some one to give you some account that saw it. We having several yards zinc sheeting lying on the ground nearly flat to run rain water to a tank, the zinc sheeting was almost covered with the dust that must have come down from above. We are on the top of the Sussex Downs, nothing but green turf, no means of getting any dust unless it came from the sky; and also all the windows of the house were covered with the dust, so remarkable to note. I, George Coleman, sender of this, my sixtieth birthday was on the 22nd, the day before I saw the dust, and that is how I so well remember. The colour of the dust was similar

to brick-dust. I hope this will be useful to you to make a true statement, as it is a true fact, so I think this is all I can assist you.—G. COLEMAN.

HEVER, EDENBRIDGE.—Saturday, February 21, was a dull, thick, stormy day, strong S.W. wind; most people thought the air was full of driving mist and took no notice of it. On going out at 10 a.m. I noticed that the air was particularly dry. Some painters were at work on a greenhouse close by, and on going up to them I found there was no dampness on the woodwork or glass. I then noticed that a fir plantation was quite discoloured on the windward side, and all the shrubs in the garden likewise. It was of a buff or light brown colour. Although this dust-storm was not nearly so severe as an ordinary one in Egypt in March, still one was reminded of the latter, and it is rather a curious fact that out of many neighbours I have spoken to about it, none noticed it except one family, four miles from here, who had lived in Tangiers, etc., a good deal, and who recognised it also as a dust-storm. The dry wind, full of dust, went on all the morning; in the afternoon it turned to rain, when the trees and shrubs showed signs of muddy rain, and our windows were badly discoloured. Directly I noticed it I said, "I am sure that dust comes from North Africa," much to the surprise, not to say unbelief, of my friends.—MOWBRAY V. CHARRINGTON, *March* 2.

JUNIPER HILL, REIGATE.—Height, 708·4 feet above the sea, facing south. Saturday, February 21. Wind, 9 to 11 a.m., W.S.W. to S.S.W., increased in severity till sundown, when it shifted back to W. and fell later. Rain at 9 p.m. From 9 a.m. till 2 p.m. the sun was shining brightly through a haze similar to the khamsin haze in Egypt, then the sun was obscured. The sky cleared of mist about 4 p.m. Evergreen trees covered with chocolate-coloured dust were noticed first at 11 a.m. By 4 p.m. the trees were all of uniform colour. The dust was silky to the touch and slightly iridescent; none was analysed. The dust must have fallen between sunrise and 4 p.m. No rain fell till 9 p.m.—EDWIN FRESHFIELD.

GUILDFORD.—The dust-storm was most noticeable in this neighbourhood on the morning of Saturday, February 21. I was riding through Woking village, when I noticed a yellow fog-like cloud apparently passing over Merrow Downs, and I pointed the same out to my son who was riding with me. On turning into a certain private road, off the London Road, which is edged with conifers, every tree looked as if it had been brushed upwards with a damp paint brush covered with fine mud, and I remarked to my son that the wind must have been very powerful to have brought, as I thought, the land surface on to the trees, as in August. But on getting into Clandon Park I found all the elm-trees as well as the conifers, covered exactly in the same way on the west side, where there was neither road nor field to give the dust, and on reaching home I found my yew hedges similarly treated. On putting some of the leaves under the microscope I found them as it were painted with the minutest dust, which was neither red nor grey, but the colour of common fuller's earth.—ARTHUR H. BOWLES, *March* 9.

WITLEY, GODALMING.—On Saturday last we had such a remarkable dust-storm, worst about mid-day, that I think you will like to have it reported. The wind was very high at 7 a.m. and continued so all day. There was also a great "fog," which is unusual with a high wind, though we do sometimes get "sea-fret" with a Southerly, South-easterly, or South-westerly wind, more especially the first. Several people who went out of doors complained of the dreadful dust in their eyes and nostrils, and on interrogating our gardener, who has lived here for over 30 years, I learned that the supposed fog was not damp, but dry, very fine dust, and he had never seen anything like it before. It certainly was very unusual to see the heavy clouds passing quickly over the sun as its beams struggled to get through, and yet to see the dense atmosphere and a strong wind

blowing too. This morning, after the rain of last night, I saw on the window sills, south and west, yellow dust, but it was like cement and could not be swept up. I therefore had it washed off two window sills, south and west, and from two south-east windows, and I send you the water, though I fear the dust was so fine that much of it was retained in the soft cloth we used, which was left yellow. I tasted the water from the window I washed; it was not salt. Saturday was a very warm day.—JULIANA FOSTER, *February* 23.

ENFIELD.—On Saturday, February 21, the air was very hazy as if full of dust, and I found that during that day, and, I believe, the following night (21-22) a considerable amount of dust fell, so as to turn a newly cindered pathway from black to red-brown. It also was quite apparent on leaves of plants. We have had no muddy rain. There was considerable wind on both 21st and 22nd ult.—A. WALKER, Major-General, *March* 2.

HAVERING GRANGE, ROMFORD.—On Saturday, February 21, a great amount of grey dust fell at Havering, and owing to the previous showers adhered to the branches and stems of the trees, hedges, buildings, etc. The conifers collected most and looked as if they were powdered with flour. The dust did not fall with the rain, but before it. It all came from the west and south-west, and adhered to that side of the trees, etc., only. This was my gardener's account, and he called attention to it when I returned home on Monday. Some of it was still visible on the window-boxes, but there was none in the rain-gauge. My gardener is a trained observer, and attends to the rain-gauge and sunshine recorder when I am away. This grey dust was observed by many of my friends all over Essex, and especially on the grass at the golf grounds at Romford. I myself was at Penzance, and could not help observing the dark atmosphere in the morning at breakfast and after. At the time there was no rain, but the atmosphere had the appearance of a London fog blowing over high up, and I remarked to my relatives with whom I was staying that one did not come all that way for a London fog.—G. P. HOPE, *March* 3.

IPSWICH.—On Sunday morning, February 22, at as nearly as possible 10.35, a few very large drops of rain fell here, and my daughter and I both noticed that they looked red on the pavement. We thought no more of it till we read the letters on Tuesday morning; and as the drops had not been sufficient nor lasted long enough for me to trouble to raise my umbrella, I thought I might find traces of the red on my bonnet, and so it proved, for some embroidered chiffon on the bonnet was quite fringed with red rust colour. I could not discover of what substance, as it had caught only in the floss-silk of the embroidery, and I could not even brush it out. Had the rain amounted to a shower no doubt many people would have noticed it, but there were only a few drops, lasting not more than a minute or two.—CONSTANCE WILLIMOTT, *March* 2.

HIGHFIELD VICARAGE, SOUTHAMPTON.—Last Sunday week, February 22, between 11 and 12 o'clock, the sky was completely covered with a thick yellow cloud, exactly like a London fog, too thick for sufficient light to penetrate to read by. The darkness lasted about an hour. When it had passed, the windows, which had, I suppose, been damp, were covered with yellow sand, looking as if gravel had been splashed up against them by heavy rain. North, east, and south were equally covered, and we had to clean all round the house on Monday. This is a high house, and the upper stories were as dirty as the lower ones. When I went into the garden I was surprised to find the seats and the backs of the garden chairs covered with a layer of yellow sand, which adhered to the wood wherever it was damp; the rest had been blown away. In the cottages near us the rain-water butts were covered with a thick layer of sand, which floated on the top of the water.—ISABELLA D. E. SILVER, *March* 2.

.BLANDFORD, DORSET.—We had the dust here to a remarkable degree. On rising on the morning of February 21, my servants, and later, myself and sons,

saw our windows to the south-east of my house a mass of reddish rain-drops and grey sand. It was like looking out on a London fog. All the windows had more or less of this, to me, unaccountable dust, but the north-west one the least.—J. CROFTON, *March* 17.

SCORRIER, CORNWALL.—Another dust-fall occurred here yesterday, Sunday 22, similar to that of January 22, 1902, only yesterday's fall was, I fancy, heavier, and the dust of a redder colour. The weather conditions were the same as during the previous fall, viz. a very strong South-west wind accompanied by driving wet drizzle. My attention, as before, was attracted to the fall by the state of my frame lights. On this occasion, too, it was very noticeable on the large square slate slabs forming the flooring of my kennels. The contents of a large tub supplied with water from the roof of a greenhouse turned a dirty grey colour. I took up a bottleful of this yesterday afternoon during the fall, and am sending it to you. The sediment may settle and afford you opportunity for analysis. During the evening the wind shifted to North-west with hail showers, and these I found in the morning had washed the dust on the kennel flooring into patches, so that I was able to take up some on a knife.—E. H. WILLIAMS, *February* 23.

MENHENIOT VICARAGE, LISKEARD.—On Sunday morning, February 22, at 8.30 a.m., a thick orange coloured fog came on. It was very different to our country white fogs, one of which succeeded it. When the coloured fog cleared away the sills of the windows, garden seats, etc., were covered with a red deposit. This was more noticeable in water-tanks, where the water looked quite red. At Merrymeet, 3 miles from here, I was told by a gentleman that the animals refused to drink the water. Last year, on Wednesday, February 26,[1] 1902, the same red deposit came down in heavy rain during a funeral here, and stained the open books and white surplices of the choir. I should mention that rain fell during the coloured fog, and both this year and last a high wind was blowing.—F. J. HAMMOND, *March* 4.

WHITEMEAD PARK, COLEFORD.—On Sunday, February 22, very heavy rain fell over the whole of this part of Gloucestershire and Monmouthshire, and on Monday the 23rd I was one of a committee of the Lydney Bench of Magistrates to inspect, amongst other things, the water-supply to a number of licensed houses in the district lying on the north side of the Severn from Aylburton to Severn Bridge, and we were surprised to find the rain-water butts were full of water of a yellowish brown colour, with the faintest tinge of pink in it, and on inquiry we were told that all the rain that fell in the preceding night was of this character. After the matter had come under our notice we were particular in examining the supplies of rain-water that had been caught at the various houses we visited, and we were informed that the discoloration was so marked that it had been universally noticed. I have since then made inquiries of the Crown woodman of the Forest of Dean, and other Crown officials in this district, and I have been informed that over the entire district, extending from Wentwood on the north-east of Newport to Little Dean on the east side of the Forest of Dean, and from the Severn at Lydney northwards across the Forest to nearly Ross, the same fact was observed. This area would, roughly speaking, be 25 miles by 14 miles. I also noticed that up to last Thursday, the 26th ult., the clear pools in places where, from the nature of the situation, no streams could carry any muddy water into them, were still discoloured, showing the extremely fine character of the matter held in suspension.—PHILIP BAYLIS, *March* 2.

PONTARDULAIS, GLAMORGAN.—On going out on Sunday morning I happened to peep into the water-tank, but to my intense surprise I found not clear water, but a yellowish muddy rain. I thought at once that it was the work of some mischievous persons the previous night, but on going to church I found out

[1] Wednesday, January 22 (?)—H. R. M.

that the curious colour was general. The sky assumed a very curious tint which to my mind was due to the mixture of the nimbus and the reddish or yellowish earthy matter, hence giving a curious green, which is very unusual. The day and the previous night were oppressively hot and close, but strange to say the morning was a typical spring one. The afternoon was somewhat stifling, reminding one of the sirocco or some kindred wind. The town from which I write, Pontardulais, is situated under the foot of a spur of the Black Mountain, seven miles inland from the head of the Barry Inlet. Hence you will see that this place is a very wet one, and indeed it has rained continuously since Christmas.—EDGAR DAVIES, *March* 6.

LLANDOVERY.—A phenomenon occurred here this morning which may possibly be of interest to observers of rainfall. The night had been fine, but rain commenced falling slightly before 9 a.m., soon after which hour very heavy clouds of a peculiar dark yellowish appearance came over from the south-west, and rain fell heavily for a few minutes, accompanied by strong gusts of wind from the same direction. After the storm passed I happened to notice that the rain-water in a collecting cask outside my window, which before the storm was quite clear, was of a deep yellow clay colour. On examining the rain gauge, which had been emptied just before the storm commenced, I found that the water in it was of the same character. The quantity which fell during the storm was about ·30 in. A relative who lives less than a mile from my house afterwards told me that his rain-water was fouled at the same time.—F. H. PERKINS, *February* 22.

H.M.S. *Prometheus*, Channel Squadron, BEREHAVEN.—The dust-fall was experienced on the night of February 20 last, in lat. 46° 40′ N., long. 11° 50′ W., when the Channel Squadron was on the passage from Berehaven to Madeira. The weather was dull and misty at the time, wind about S.W., moderate breeze, force 4. The dust was of a reddish hue, and I particularly noticed it on the rigging, rails, etc., of the ship.—MORGAN SINGER, Commander R.N., *March* 19.

PARTICK, GLASGOW.—I am an engineer on the steam-dredger *Mexico*, and when coming to Glasgow on a voyage from Vera Cruz in the same latitude as the northern point of Madeira, and about 200 miles west, with a slight wind from the Eastward, our decks were covered to the depth of a quarter of an inch with a very fine dust of a dark grey colour. This took place in the afternoon about 2 p.m. on February 20 last. I may state that the same night and for three consecutive days we had strong Southerly gales.—A. H. C. HINDE.

In order to ascertain whether the composition of the dust threw any light on its origin, all the samples which we obtained (about fifty in number, including some from the Continent and some collected at sea) were submitted to the Geological Survey and examined by Dr. J. S. Flett, whose report is given on p. 73.

When we attempt to trace the origin of the dust, the fact that it was brought to our islands by a South-westerly wind leads us to consider the meteorological conditions prevailing over the Atlantic Ocean on the days of dust-fall and those immediately preceding. Figs. 5-10 give the distribution of atmospheric pressure and the circulation of the wind over the northern Atlantic at 8 a.m. on each of the days, from February 17 to 22nd inclusive.[1] The constant features of all the maps are (1) a well-developed anticyclonic system over the south-west of Europe, and (2) a very large area of low pressure covering the northern Atlantic. The

[1] These charts and diagrams for Figs. 5-13 were prepared in the Meteorological Office.

centre of the former was over central Germany on the morning of the 17th, and thence it travelled slowly in a south-westerly direction, till on the 22nd it lay over the Iberian Peninsula. The minimum of the northern low pressure system remained well to the north of the track of steamers crossing the Atlantic, and consequently its position cannot

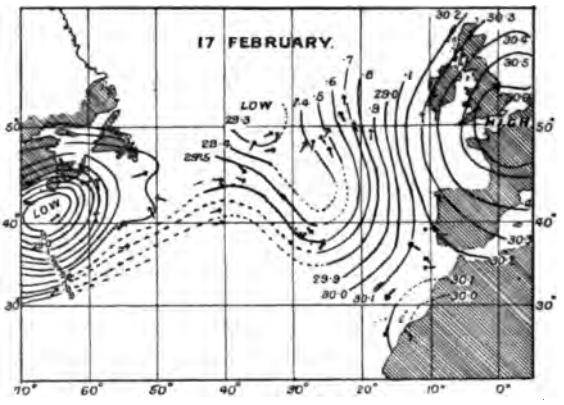


FIG. 5.

be fixed. Turning to the individual maps, we find that there is evidence for the existence of a second low pressure system over north-west Africa on the morning of the 17th (Fig. 5). This caused North-easterly winds in the neighbourhood of the Canary Islands, but north of lat. 34° N. a

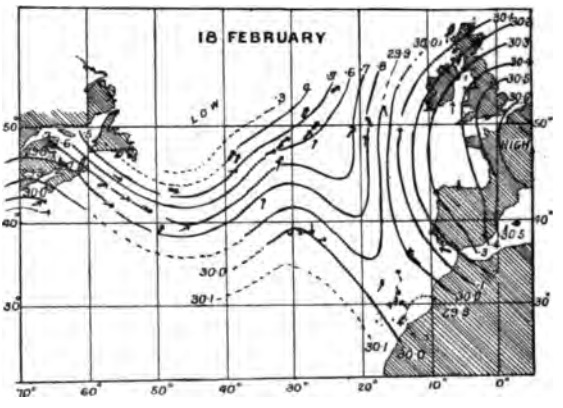


FIG. 6.

South-easterly wind blew off the African coast. On the morning of the 18th (Fig. 6) this second low pressure system had moved farther to the south, so that a larger portion of the coast was under the influence of the South-east wind. Another low pressure system, secondary to the main disturbance in the north, is shown in the region between the Azores and the Iberian Peninsula, and caused Northerly to Westerly

winds to prevail at the Azores.[1] On the 19th (Fig. 7) the low pressure system off the African coast had moved still farther south, and a still larger portion of the coast was affected by the South-east wind. A second high pressure area had developed near the Azores, where the wind

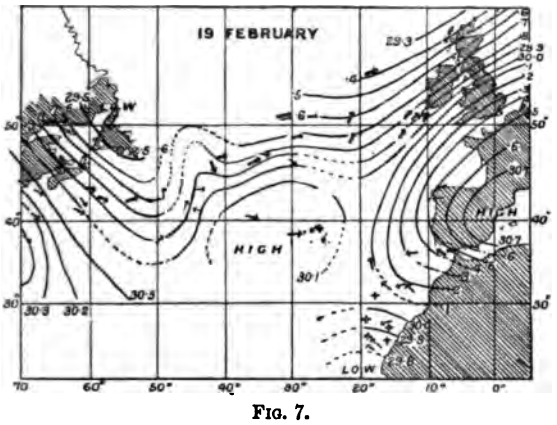


FIG. 7.

at 8 a.m. was between North and West. On the following day this high pressure area had disappeared, and the whole of the North Atlantic, from Nova Scotia in the west to the Azores in the south and Ireland in the east, was covered by a vast low pressure system, and the wind was

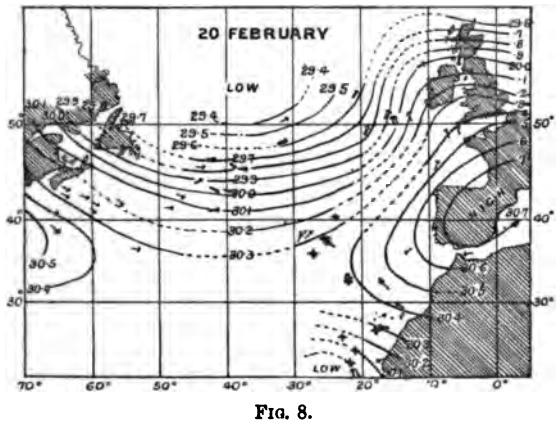


FIG. 8.

consequently Westerly to South-westerly or Southerly throughout. On the two following days (21st and 22nd, Figs. 9 and 10) the conditions over the western part of the ocean suffered little change.

The distribution of pressure over the continent of Europe had been of a pronounced westerly or south-westerly type for several days before the dust-fall was observed. The maps for the 21st and 22nd

[1] The maps of the Deutsche Seewarte, published in Dr. Herrmann's paper already referred to, contain a few more observations from these regions. In those maps the isobar for 760 mms. (29·92 ins.) is drawn as a closed curve.

are reproduced in Fig. 11. They all show a steep gradient for Westerly or South-westerly winds over the north-west of the continent. The Italian *Weather Report* for the 22nd records a rather shallow, but well-marked, depression over northern Italy; this has been included in the maps reproduced.

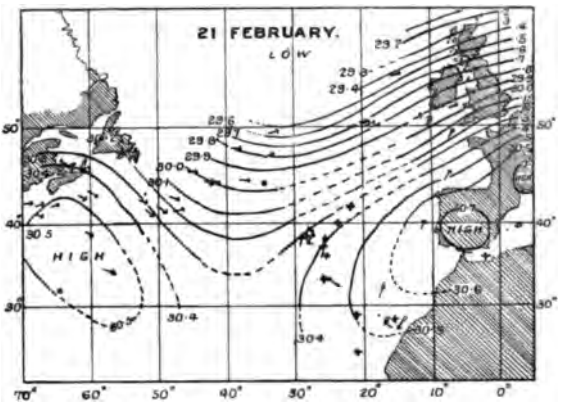


FIG. 9.

The temperature observations, as given in the Daily Reports of the various countries of central and north-western Europe, show the following points of interest. On the 21st readings over England were well above 50°, but the adjacent parts of the Continent, not being affected by

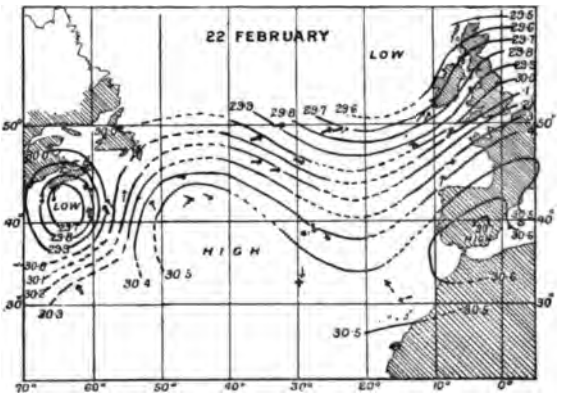


FIG. 10.

the warm South-westerly air current which spread over our islands from the Atlantic, experienced considerably lower temperatures. On the 22nd temperatures had fallen over England, and we find the 50° isotherm skirting along the extreme south-west of Ireland and England, and then enclosing a long tongue-shaped area on the northern side of the Alps extending from the shores of the Bay of Biscay as far eastward as Austria. The position of this warm area is suggestive of a foehn effect, and renders

it probable that the unusually high temperatures and great dryness which in many cases accompanied the dust-fall were in part due to the descent of air currents causing warming by dynamical heating.

With the help of the above maps, an attempt was made to determine from whence the air which reached the north-west of Europe on the morning of February 22 was derived, independently of any pre-conceived theories of the origin of the dust. With this object trajectories for this air were drawn in a manner similar to that employed in a paper on the storm of February 26 and 27, 1903, recently read before this Society by Dr. W. N. Shaw, F.R.S.[1] A sheet of tracing paper, on which the outline

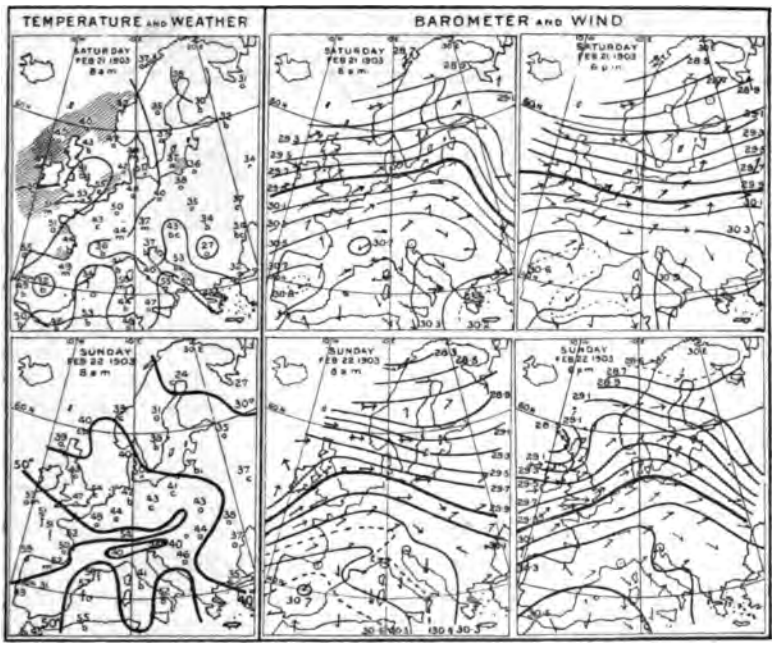


FIG. 11.—Weather over Western Europe, February 21 and 22.

of the continent of Europe was marked, was placed over the map for the 22nd, and on it lines were drawn from three selected points (Stornoway, the extreme south-east of Ireland, and central Wales) in the direction of the winds shown on the map, and proportionate in length to the distance which the air may be supposed to have travelled in the 12 hour interval between 8 a.m. on the 22nd and 8 p.m. on the 21st. The winds on the western coast of the British Isles were generally reported as of force 6 or 7 on the Beaufort scale, and if we assume that this corresponds to a velocity of rather more than 30 miles per hour, the distance travelled in 12 hours would be approximately 400 miles. The constancy of the isobars in this case justifies the extension of the trajectories over so long an interval. In this manner the positions which the air occupied on the evening of the 21st were approximately found. The tracing paper was then placed over

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. **29**, p. 233.

the map for 8 a.m. on the 21st, and the paths of the air during the previous 24 hours were marked on it, after which a similar process was gone through with the remaining maps. In cases where no observations of wind were available, the direction and length of the successive steps were estimated from the direction and distance apart of the isobars.

The trajectories shown in Fig. 12 were obtained in this manner. They seem to show that the air which reached the British Isles on the morning of the 22nd was derived from three distinct sources. The north of Scotland, where temperature was low, was supplied with air from the northern Atlantic (Trajectory A). Ireland and the north of England were deriving their air from the central Atlantic, from the northern side of the high pressure area shown near the Azores on the 19th (Trajectory B). The trajectory (C) of the air which reached central Wales may be followed back in a south-westerly direction to the neighbourhood of the Azores on

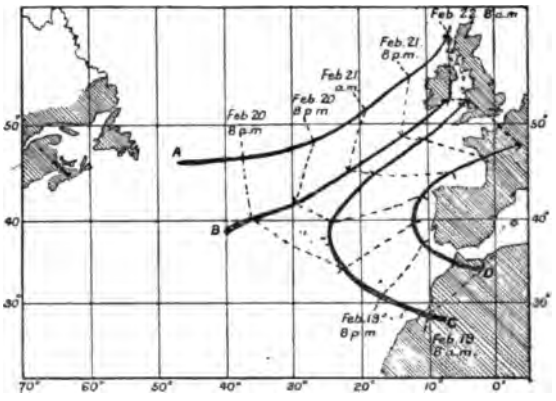


FIG. 12.—Trajectories.

the evening of the 20th, but here it leads to the south, and ultimately to the south-east, and carries us back to the north-west coast of Africa (lat. 30° N.) on the morning of the 19th. A fourth trajectory D traces the course of the air which left the extreme north-west of Africa at the same time.

There is therefore reason to believe that the air which reached the southern part of England on the morning of the 22nd started from the north-west coast of Africa about the 19th, and if this is so it forms strong evidence in favour of the dust being of African origin, and of its having travelled to north-west Europe by paths not very different from those indicated by the curves C and D. The trajectories are drawn to represent the path of the air at sea level, and the dust must have travelled at a considerably higher level. The fact that on the morning of the 22nd the snow on Mount Pico at the Azores (7460 ft.) was observed to have a yellow tinge, is *primâ facie* evidence that the dust reached a height of more than 7500 ft., and we shall see subsequently that the dust-falls in many parts of the continent of Europe admit of easy explanation if we assume that it travelled at some such altitude. As Dr. Herrmann has pointed out, it is not probable that the dust travelled at a constant altitude, or even that it was associated with the

same body of air throughout its journey. Gravitational forces were acting on it throughout its course, and the increased heat-absorbing and radiating power of the dust-laden air must have given rise to active convection currents. All that can therefore be claimed for the trajectories is that they represent the general features of the paths by which the dust reached Europe on the 22nd.

As might be expected from the general similarity of the isobaric maps, the trajectories of the air which reached Europe on the morning of the 21st (Fig. 13) are very similar to those already dealt with. The unfortunate scarcity of observations from the area between lats. 40° N. and 50° N. and long. 10° W. and 30° W. on the days in question makes it difficult to draw them with great precision. The most important difference is shown by the trajectory H. The isobaric gradient off the Spanish coast was considerably steeper on the 19th than on the

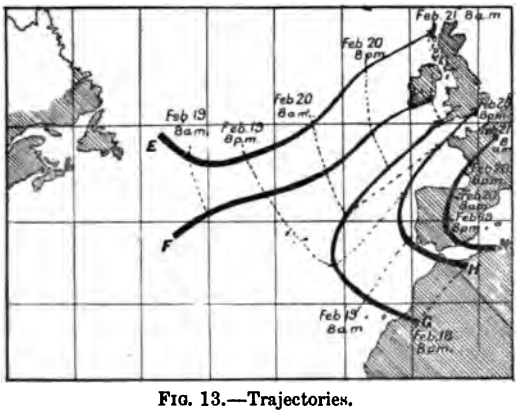


FIG. 13.—Trajectories.

20th, and consequently the velocities used in constructing H were considerably greater than those used in the case of D (Fig. 12). H when continued northward reaches the south-east of England as early as 8 p.m. on the 20th. The trajectory K represents the path of the air which reached central France on the morning of the 21st. Its course lies almost entirely overland, it carried no dust, and is interesting in view of the relatively low temperatures experienced on the Continent on this morning which have been already referred to.

If we assume that the dust travelled to Europe by paths not greatly different from those traced by the trajectories, its distribution over Europe and the North Atlantic is easily explained. The positions in which dust was met with at sea north of lat. 20° N. are shown on the maps.[1] The isobars are based on observations made at 8 a.m. local time, but in many cases the ships' logs do not give the hour at which the phenomenon was observed, and the entries on the maps must be understood to mean that dust was met with in the positions indicated in the course of the day for which the map gives the meteorological conditions at 8 a.m. The only one of these observations which at first sight does not seem to support the theory, is one by the German sailing ship *Carl* in lat. 39° N., long. 26° W. on the 19th. The wind at 8 a.m. on that

[1] The positions are shown in Figs. 5-10 by means of small crosses.

morning was North-westerly at Ponta Delgada, and presumably also at the point in question, but the charts published by Dr. Herrmann show two observations of South-easterly winds in positions slightly south-east of the Azores. This South-easterly wind must have spread to the position in question during the day, and probably carried some dust with it. The German observation does not mention the hour at which dust was first encountered.

In addition to the observations shown on the maps, many reports of dust storms off the African coast and in the Atlantic, south of lat. 20° N., both on the days under discussion and earlier, have come to hand. These have not been dealt with further, but they must be regarded as evidence of the occurrence of unusually severe disturbances over the continent of Africa of the meteorology of which we unfortunately know so little.

The different points of origin of the trajectories B and C (Fig. 12) afford a simple explanation of the distribution of dust over the British Isles. From places outside the shaded area in Fig. 1, we have only one apparently well-authenticated observation of dust, viz. that at Cavan, and a few somewhat doubtful ones. Unfortunately, in the case of the Cavan fall the dust was not collected and submitted to examination by a mineralogical expert, and in the light of what Dr. Flett has said as to the invariable presence of local admixtures in all deposits examined by him, we are not justified in regarding this isolated observation as conclusive evidence of the wider distribution of dust of the same kind as that collected elsewhere. The distribution of the dust over the Continent also admits of easy explanation. The complete absence of deposit from Spain and southern France, countries nearest to the assumed source of the dust, has attracted some attention, but the course of the trajectory D shows that we ought to expect no dust on its eastern side. The region between the trajectories C and D may, in fact, be looked upon as the gateway by which the dust entered Europe; air on the inner or eastern side would have come from the Mediterranean over Spain, and on the outer or western side would have come from the western Atlantic. The falls farther to the east in Switzerland, Germany, and Austria also cause little difficulty, if we assume that the dust travelled at an elevation of from 3000 ft. to 10,000 ft. Many of the high-level stations on the northern side of the Alps experienced gales from between West-south-west and North-west during the night from the 21st to the 22nd. The following wind observations were made (Beaufort Scale) on the morning of the 22nd: Puy de Dôme (4813 ft.), W. 7; Säntis (8202 ft.), W.S.W. 9; Zugspitze (9679 ft.), N.W. 7; Wendelstein (5666 ft.), W. 8; and Grosse Belchen (4577 ft.), W. 5. If we assign the comparatively small velocity of 40 miles an hour to this air, it would travel 500 miles in twelve hours, and the dust-laden air which we have traced to the shores of the Bay of Biscay (trajectory D) on the evening of the 21st would reach the region in which dust was observed on the morning of the 22nd at exactly the right time to produce the phenomenon.

Even in the case of the most southerly dust-falls, which might be supposed to have occurred outside the region affected by the Westerly air current, there is no reason to suppose that the path followed by the dust differed from that described above. The low pressure system over the

valley of the Po caused Northerly to North-easterly winds at many of the elevated stations on the 22nd, so that it is probable that some of the dust which was brought to central Europe by the Westerly air current was carried southward by this Northerly to North-easterly current. An observer at Blumau near Fürstenfeld, in the west of Styria, mentions that the dust cloud came from the north-east.

Note on the Microscopic Characters of the "Blood Rain" that fell over the South of England on February 22, 1903. By JOHN S. FLETT, M.A., D.Sc.

(By permission of the Director of H.M. Geological Survey.)

A LARGE number of specimens of the dust and sand which fell in the southern counties of England and Wales on February 22, 1903, were sent to me by the Meteorological Office, and by Dr. H. R. Mill, in the course of the few weeks following the dust-fall. Only the general results of the investigation will be given here, as it will be seen from the subsequent part of this report that the specimens varied so much in character, and were so frequently impure, that it is only by a method of exclusion that any conclusions can be attained regarding the nature of that part of the material which was of foreign origin. Many of the specimens were in the form of muddy water collected from rain gauges. Others were dry powders collected from rain gauges or from window sills, conservatory roofs, or other objects in the open air. In many cases the exact method in which the sample had been collected was not stated.

It was obvious, at the first glance at the collection, that it presented a great variety of characters, and this was enough to awaken a suspicion regarding the purity of the samples, and to lead to a search for material which might be of local origin. Some of the dusts were nearly black, and proved to consist largely of soot and organic matter; others were nearly white and were full of vegetable hairs; some were pale gray or dark gray, from various causes; but the majority were pale brown or buff of different shades.

Most of the material was exceedingly fine grained, but in some cases there were rock fragments 2 millimetres (0·08 in.) in diameter, and many of the sands had grains of an average size of half a millimetre (0·02 in.). In these cases there could be no doubt of the local derivation of the coarser sediment; and on further examination it was clear that the only part of the dust that could reasonably be supposed to have come from beyond the British Isles was an exceedingly fine reddish clay, none of whose particles could greatly exceed ·01 millimetre (·0004 in.) in diameter.

Organic impurities were so common that there was practically no dust which did not contain them, and in some they formed the bulk of the deposit. When heated on platinum foil, most of the samples darkened, giving out organic vapours, and subsequently the carbonized materials burned slowly, leaving a residue which was gray or brown. Some specimens were little changed in volume or in colour by incineration at a dull red heat for a minute or two, others were entirely altered in appearance. The organic matter, however, being comparatively easily

detected under the microscope, could be readily allowed for, and was hence less confusing, so far as concerns the real purpose of this investigation, than the mineral impurities.

Plant debris was very abundant. Vegetable hairs occurred everywhere, often in great quantity; fragments of epidermis and of cuticle, silica skeletons of the epidermis of grasses, parenchymatous and prosenchymatous tissue, woody fibres (occasionally), pollen, spores of cryptogams (either singly or in masses), spore cases, resting spores of fungi, hyphae, and various unicellular, or filiform, algae were all to be found. Diatoms were not frequent—in fact they were comparatively rare, as were also desmids. Many of the samples sent in in a moist condition were full of bacteria.

Animal debris was less conspicuous. Some of the dusts contained scales of insects, and what seemed to be fragments of the elytra of beetles and remains of diptera. These, however, did not bulk largely in any of the specimens.

Soot was abundant: some dusts contained little else. It seemed to consist partly of charred, blackened matter which was still to some extent combustible, and partly of black grains which were unaltered on heating. All the dusts which were tested with a magnet yielded black attractable particles. Examined under the microscope, some of these were perfect spheres, others were pear shaped, but many were angular or irregular in form. When treated with an acid solution of copper sulphate, some of these black particles proved to consist of metallic iron, as they were soon covered with a red film of copper. These were all angular, resembling minute iron-filings; none of the globular bodies reduced the solution. This, however, does not of necessity establish that they consist of magnetic iron oxide inside, as they may only be covered with a thin film of this nature, while their interior might be unoxidised. They were too small to test for malleability. Such particles, both globular and angular, are well known to occur in ordinary soot.

Mr. Allan B. Dick, whose wide experience of dust and sand deposits enables him to speak on this subject with authority, assures me that soot contains also fine slaggy or glassy, rounded bodies, isotropic and sometimes vesicular. This is in accordance with the results[1] of M. W. Prinz, who has found such bodies in the dust-fall of Belgium. In all probability many of the isotropic particles to be subsequently described are of this origin.

A few other sources of error may be mentioned before we pass to consider the mineral constituents of the dust. Some specimens were in medicine bottles which had not been thoroughly cleaned, with the result that a precipitate had formed. Other moist specimens had fermented and were full of moulds and bacteria. One pale-coloured "dust" was mostly gypsum and salt crystals. These, of course, are frequent on the surface of deserts, but as this sample came from the decks of a steamer, and there was no other of the same kind, it was reasonable to suspect that it had something to do with the salt crust from the ship's funnels.

Among the mineral constituents of the dust, fragments of rock were unusual, minute mineral grains predominated. Of these the following were present in different samples: — quartz, orthoclase, plagioclase,

[1] Prinz W., "Analyse de la boue tombée en Belgique le 22 Février 1903." *Ciel et Terre*, March 16, 1903, p. 31.

hornblende, chlorite, tourmaline (?), zircon, muscovite, cherty silica, calcite, iron oxides, and fine argillaceous debris. It is unlikely that any but the first and the last of this list were of foreign derivation.

Nearly all the samples were tested in dilute (10 per cent) hydrochloric acid. For the most part they effervesced freely; it was noticed, however, that some contained very little carbonate of lime. All specimens collected from the neighbourhood of the Chalk and from the east of England, where calcareous rocks are common, contained carbonate of lime usually in abundance. (There were only a very few exceptions to this rule; they will be referred to later on.) Those from the west of England and South Wales were sometimes calcareous, sometimes not.

Without doubt this calcite was mostly of local origin. Often the samples from Kent and Surrey showed small fragments of finely granular chalk. With it there was usually flint debris. From the west of England no specimens showed chalk, but when calcareous, they contained little sparkling rhombohedra of crystalline calcite. Now the older limestones of that region are mostly crystalline. The significance of this coincidence is obvious. Where carbonate of lime was abundant it was inferred that the dust was highly impure; and, as a rule, other indications were not lacking to corroborate this.

Some of the dusts which were free from carbonate of lime were silica sand, others were of vegetable composition. In neither case were they foreign. But there were some samples of fine pale brown clay which contained little of this material, and these, there is reason to believe, were approximately pure samples of the true blood-rain dust. They were mostly from Cornwall and South Wales; and as the wind was from the South-west, these are precisely the districts in which it is likely that there would be least local admixture in the dust cloud.

It should be remarked that some of the Cornish and Devonshire dusts were more calcareous than might have been expected. But extreme caution is necessary in drawing any conclusions from this. Limestone is extensively used for road-mending in some counties, and calcareous matter is never absent from the dust of towns and villages. As we have found by sad experience in this laboratory, the demolition of old houses in the vicinity will fill the air for weeks with fine impalpable calcareous debris.

The minerals of crystalline igneous rocks, such as felspar, hornblende, and augite, were very rare. In every case their presence was due to contamination. From Horsham two samples were sent. One was a pale buff dust with a fair admixture of chalk, and very much the sort of dust one would expect from a knowledge of the locality. The other was non-calcareous, but contained plagioclase, felspar, augite, and possibly hypersthene. It was unique in the collection, and can hardly be anything else than the dust of a road or street which is paved with some kind of dolerite. Another dust, from Kent, contained orthoclase, plagioclase, and hornblende, and we cannot help suspecting that somewhere in the vicinity there is a road or street laid with Guernsey or Charnwood diorite. The "blood rain" was certainly not volcanic.

Often it was possible to establish that the dusts had a recognisable local character. The chalk and flint in the Surrey, Kent, and Sussex samples were absent in Cornwall, as already stated, but there it was

more common to find felspar and muscovite. Some of the specimens from South Wales were darker and more sooty than those from the south-east of England. Still the predominance of brown and pale brown colours was more general than should have been the case if most of the dusts were entirely local, and led to the conclusion that there was in all the dusts a fine-grained brown or red material which was not English. No doubt some soils of the Permian and New Red districts of the west of England are as red, or redder, in colour than any of the samples, but especially in the east of England the red colour of the dust was a striking characteristic.

As regards the size of the particles, it should be stated that many of the dusts which there was reason to suspect were fairly pure were really impalpable, and when rubbed between two microscopic coverglasses gave no evidence of grittiness. Most specimens, however, contained more or less quartzose sand, mostly angular, and often on an average 0·1 millimetre (0·004 in.) in diameter. I do not think it at all likely that any particles so large as these were part of the original "blood-rain" dust, and when they were common they were taken as indicating a local origin for most of the sample.

I have dilated, perhaps at unnecessary length, on the nature and abundance of the impurities. For this there are several reasons. In the literature of dust-falls there are many descriptions of "blood rains," based mostly on the examination of one or a few specimens by different experts. These often differ so much in their details that there is room for regret that all the samples had not been placed in the hands of one competent petrologist. The dust-cloud which apparently crossed England on February 22, 1903, had probably come from a great distance, and should have been fairly homogeneous. The variety of the samples collected in itself proves that most of them were far from pure "blood rain."

Moreover, the impurities were often all that it was possible to describe. There is at present a fairly definite limit to the range of microscopic mineralogy. When fragments have less than a certain size, say 0·01 mm. in diameter, it is no longer possible to make out their true nature with absolute certainty. The local ingredients in these dusts were often large enough to be easily recognisable. The one material which was common to all the specimens was a very fine red or brown clay, which contained no ingredients over ·01 mm. in diameter. On an average they were about the size of a red blood corpuscle (·006 mm. diameter). Mineral particles so small as these no longer give polarisation colours which are of any value in determination. It will be clear that the ordinary characteristics of minerals in thin sections are not applicable to these fine powders when I say that often fragments which were proved to be *calcite* gave only the red and blue of the first and second orders. Under these conditions quartz is sensibly isotropic even when tested with a selenite plate. Convergent light gave no satisfactory results, as even the best lenses give "ghosts" which obscure altogether the very indefinite axial figures yielded by such minute grains. Hence it results that the petrologist is obliged to confess that the mineralogical characters of one of the commonest of all rocks, namely *clay*, are very imperfectly known to him at the present day.

This red dust or true "blood-rain" dust, then, had apparently the following characters. Its particles varied from ·01 to ·001 mm. in diameter. Its colour was brown or reddish brown. When pure, it contained little carbonate of lime. Tested with hydrochloric acid it yielded a solution containing iron and alumina. It caked together firmly when dry, and had a slight earthy smell. Under the microscope some of the particles were brown from being coated with iron oxide, but otherwise they were pale green or greenish yellow. Some were rounded or globular (*vide supra*, as regards soot) and isotropic, but most were scaly, flattened, irregular. Many gave polarisation colours which were high for particles so minute. These have often been referred to as mica, but this is certainly not the case, as they give colours when lying flat which are about twice as high as mica gives when looked at edgewise. What they are is not known. Some little needles were probably rutile. Very fine colourless, angular grains, from their refractive index, were perhaps quartz; but except when fairly large they had no perceptible effect on polarised light. Small elongated rods were often seen, which polarised strongly and gave a straight extinction. There was nothing to indicate their true nature.

The most careful mineralogical studies of clays with which I am acquainted are those of Hutchings,[1] and there is little in this red clay which differs very greatly from what he has found in the studies of British clays. Neither are there any features which differ very greatly from what Bauer has described in his microscopic notes on the laterite deposits of Socotra.[2] Whether this is a dust of tropical or of temperate latitudes can hardly be established by means of the microscope. And when there is so much in the dust-fall that is assuredly of local origin, it is not safe to infer that only the coarser fragments are British. Rather may we believe that fine local dust should not be absent, but mingled freely with the foreign dust which came from beyond the sea.

The chemical composition of two fairly pure samples collected in South Wales is given in the following analyses, for which I am indebted to Mr. C. A. Seyler, B.Sc., F.I.C. The first specimen was collected by Mr. J. R. Lever at his house at Norton Road, near the Mumbles, Swansea. The second analysis is of another specimen collected near Swansea. Both were brownish red powders, very fine grained, and darkening on ignition.

	I.	II.	III.
SiO_2	54·03	57·20	69·11
Al_2O_3	28·50	17·26	20·85
TiO_2	1·11	·94	1·13
Fe_2O_3	10·39	7·80	9·44
CaO	5·19	nil	...
MgO	·47	tr.	...
Alk	not det.	...	...
...	Loss on ignition	17·33	...
	99·69	100·53	100·53
	This powder lost about 18 per cent on ignition.		

For purposes of comparison the second analysis has been recalculated after deducting loss on ignition, and is given under III.

[1] W. H. Hutchings, *Geological Magazine*, 1891, 1894, 1896, and other years.
[2] M. Bauer, *Neues Jahrbuch für Mineralogie*, 1898, ii. p. 197.

These analyses of two samples collected at localities within a few miles of one another and both near the coast, while the wind was off the sea at the time, differ so considerably as to show that even under favourable conditions the samples were certain to contain a notable admixture of local ingredients. The Mumbles dust contains 5·19 per cent of lime and microscopic examination showed the presence of calcite, though the total bulk of the sample was too small to enable the amount of CO_2 to be estimated. Now it was collected in a *limestone* country; but the other, which was collected on sandstone, is free from carbonate of lime. On the other hand, the second dust contained a higher percentage of silica than the first. Mr. A. Strahan, F.R.S., informs me that the roads about the Mumbles are partly mended with broken limestone, while in Swansea harder and more durable stones of various kinds are employed.

It seems reasonable to infer that nearly 20 per cent of these samples was local dust, and that the pure "blood rain," which was the principal ingredient of both, was nearly quite free from carbonate of lime, contained from 50 to 60 per cent of silica, from 30 to 35 per cent of alumina and ferric oxide, and in all traces of magnesia, litania, and alkalies.

Prof. Thorpe has published in two letters to *Nature* (vol. **68**, pp. 55 and 222, 1903) the analysis of a sample of "blood rain" collected on the roof of Bayham Abbey, Lamberhurst, Surrey (made by Mr. C. Simmonds in the Government laboratory). It is as follows :—

		or calculated free from water and organic matter.
SiO_2	45·94	50·53
Al_2O_3	18·35	20·18
FeO	6·57	7·23
CaO	8·64	9·50
MgO	1·86	2·04
Na_2O	1·16	1·27
K_2O	2·30	2·53
H_2O and organic matter	9·08	...
CO_2	6·10	6·72
	100·00	100·00

This analysis agrees well, on the whole, with those by Mr. Seyler, but shows a considerably larger percentage of carbonate of lime, which confirms the results of microscopic examination of the dusts collected in the east of England. It was found also that nearly one-third of the sample was soluble on boiling in hydrochloric acid, and that alumina and ferric oxide, to an amount corresponding to 11·20 per cent and 5·43 per cent of the whole rock, passed into solution. Prof. Thorpe has shown that the Bayham Abbey dust is very similar in composition to the dust that fell in Taormina, Sicily, March 10, 1901. Except that the latter dust is coarser grained and contains more diatoms, there is no important difference in microscopic character between it and certain specimens of the English "blood rain" of February 22, 1903.

It is interesting to compare these analyses of "blood-rain" dust with those of some other argillaceous deposits (see page 79).

I. is an analysis of laterite from granite in the Seychelles (by Prof. Bush) given by Bauer.[1] It has a close similarity to the analyses above

[1] *Neues Jahrb. für Mineralogie*, 1898, vol. **2**, p. 197.

given, and suggests that the fine red dust may be derived from the laterite which is so abundant in tropical regions. It is believed by Bauer and by Holland [1] that laterite is not an ordinary clay but a fine admixture of quartz with baunite, gibbsite, diaspore, and other hydrated forms of alumina. Special investigations were made by Prof. Thorpe (*loc. cit.*) to determine whether the "blood-rain dust" had the chemical properties of laterite, but these were without positive result.

	I.	II.	III.
SiO_2	52·06	54·51	62·25
Al_2O_3	29·49	7·77	14·93
Fe_2O_3	4·64	4·57	0·74
FeO	...	...	4·64
MnO	...	...	0·07
MgO	...	2·22	3·00
CaO	tr.	14·82	5·09
Na_2O	...	0·91	4·01
K_2O	...	1·21	2·02
H_2O	14·40	0·72	3·20
P_2O_5	...	0·14	0·11
CO_2	...	12·92	...
Cl	...	...	0·06
	100·59	99·79	100·12

II. is an analysis of loess, and III. of crocyonite (both cited from Rosenbuch, *Elemente d. Gesteinslehre*, Ed. II. p. 429). This last is the fine dust which Nordenskiöld collected on melting the surface snow on the inland ice of Greenland. The analysis is by Lindström. The loess is rich in carbonate of lime, and the crocyonite contains a fair amount of alkalies. Altogether the resemblance between these analyses and that of the "blood rain" is not very great. In a recent paper by Prof. Liversidge on meteoric dusts [2] many analyses of dust deposits are given, but these do not show any great uniformity of composition. It may also be noted that there are distinct resemblances between the composition of the "blood-rain" dust and of certain abysmal red clays, though this may only be accidental.

[1] *Geological Magazine*, Dec., IV., vol. **10**, 1903, p. 60.
[2] *Jour. and Proc. Roy. Soc. N.S.W.*, vol. **36**, p. 241.

APPENDIX.

Stations reporting Dust-falls in February 1903.

An **S** indicates that specimens were sent.

MIDDLESEX.

		Date
Ealing (*Capt. Campbell Hepworth*).	.....	
Bunhill Row . .	Meteorological Office sunshine card	?22
Enfield (*Gen. Walker*) .	Dust turned newly cindered path from black to reddish brown	21, 22
Potters Bar (*H. Ellis*) .	Haze lasted from 9 a.m. to 5 p.m. on 21st, windward side of trees powdered	21

SURREY.

S Haslemere, Shottermill	(*Hon. C. Ellis*)	Shower on	22
Haslemere, Hindhead	(*Mrs. Hecht*)	Windows dirtied	22
S Witley . . .	(*Mrs. J. H. Foster*)	Dust Fog	21
Ewhurst . .	(*Miss Ewart*)	Sediment in gauge . . .	21, 22

				Date
S	Holmwood	(*Mrs. Fox*)	.....	22
	Guildford	(*A. H. Bowles*)	Dust on trees, morning of	21
	Reigate, Juniper Hill	(*Dr. E. Freshfield*)	"Dust and haze"	21
	Merstham, Upper Gatton	(*F. Druce*)	Some on night of 20th, dry on 21st, in rain on 22nd	20, 21, 22
	Leatherhead, Hawkshill	(*Miss Blake*)	Dry fall, morning of	21
	Woking	(*A. H. Bowles*)	Dust on trees, morning of	21
	Bagshot	(*W. Burgess*)	Muddy rainspots seen, morning of	22
	Cheam	(*Miss Blake*)	Dry fall	21
	Sutton	(*Miss Blake*)	,,	21
	Chertsey, Longcross	(*Admiral Carr*)	Dry, gray, powdery dust, forenoon of	21
	Wimbledon Common	(*Mrs. A. L. Lowcock*)	In rain-water barrels	22
	Barnes Common	(*Miss M. A. Twiss*)	Dry fall with a gale just before noon, on	21

KENT.

	Littlestone-on-Sea	...	Met. Office sunshine card	21, 22, 23
	Tenterden	(*J. E. Mace*)	.....	22
	Benenden	(*J. E. Mace*)	.....	
	Hythe, Sandling Park	(*L. Hardy, M.P.*)	Night of	22
	Hythe	(*W. J. Atkinson*)	.....	
S	Hythe, Hillcrest Road	(*J. B. Jordan*)	In gauge on 23rd	22
	Folkestone	(*Rev. W. Balmani*)	.....	22
S	Biddenden	(*J. E. Mace*)	.....	22
	Dover, Gladstone Terrace	(*W. H. Pendlebury*)	Dust-laden rain between 11 and 12	22
S	Dover, Buckland	(*W. Coleman*)	.....	22
	South Foreland Lighthouse	(*Rev. F. Case*)	In a misty rain at noon	22
	Dover, St. Margaret's	(*Rev. F. Case*)	.....	22
	Tunbridge Wells, Rusthall	(*H. M. Rogers in "Times"*)	.....	22
	Groombridge	("*Tunbridge Wells Advertiser*")	.....	22
	Tunbridge Wells, Langton Green	(*W. L. Sutton*)	In gauge on 23rd	22
S	Tunbridge Wells, Southborough	(*C. B. Powell*)	Rain-water discoloured	22
	Tunbridge Wells, Pembury Court	(*B. Addy*)	.....	22
	Ashford	(*W. Jarvis*)	"Yellow storm," 12.30 p.m.	22
	Edenbridge, Hever	(*M. V. Charrington*)	"Dust storm in high wind"	21
	Tonbridge, Colebrook	(*W. A. Smith*)	.....	22
	Tonbridge	(*S. W. Burgess*)	.....	"One morning."
	Tonbridge, Primrose Hill	(*G. K. Kimmins*)	Dust fell in haze during S.W. gale	21
	Upper Deal	(*Miss C. Davies*)	Heavy rain at 5 p.m. on 21st, noticed morning of	22
	Dover, Chellenden	(*Rev. J. O. Bevan*)	Probably night of	22
	Hildenborough	(*L. S. Powell*)	Fell morning of	22
	Wateringbury	(*Rev. G. M. Livett*)	"Dirty rain" noticed on morning of	23
	Canterbury	("*Thanet Guardian*," *W. G. Pidduck*)	Rain of morning of	22
	Sevenoaks	(*E. B. Milford*)	Dirty windows on morning of	23
	Luddesdown	(*W. R. Smith-Masters*)	Fog lasting from daylight till mid-day	21
	Westgate-on-Sea	(*Lt.-Col. Jones*)	Yellow opaque haze	23
	Margate	...	Met. Office sunshine card	23
	Leysdown, Sheerness	(*C. A. Till*)	Fell dry on 21st, noticed in gauge morning of	22
	Beckenham	(*P. Collins*)	Dust or mist in air	21
	Meopham	(*W. R. Smith-Masters*)	Fog lasting from daylight till mid-day	21

SUSSEX WEST.

	Bosham Creek	(*R. A. Gregory*)	.....	
	Chichester	(*R. F. Wordsworth*)	Thick yellow mist about noon	22
	Lancing	(*Miss A. Kemp*)	Evening of 21st or early morning of	22

			Date
Findon, Nr. Worthing	(*G. Coleman*)	.....	23
Compton	(*Rev. H. Marmaduke Langdale*)	Between 11 and 12 with rain	22
Henfield	(*Elden Pratt in "Sussex Daily News"*)	Chalky rain water	23, 24 ?
Rogate	(*Miss K. M. Barrow*)	Between 11 and 12 thick haze and dust on trees	21
S Horsham	(*E. G. Loder*)	Fell dry exactly like Sahara dust.	20
Horsham	(*H. Padwick*)	In rain of 22nd, the first for 3 weeks	22
S Horsham, Wimblehurst	(*Miss Allcard*)	On night of	22
Slinfold	(*J. Fullwood*)	Fell with rain	22

SUSSEX EAST.

Eastbourne	...	Met. Office sunshine card	21-24
Falmer	(*D. Bentley*)	Dust on trees "tasted briny" at 3 p.m.	21
Hastings	...	Met. Office sunshine card	22, 23
Lewes, Saxonbury	(*A. Hillman*)	On evening of	21
Horeham Road	(*Miss E. M. Moon*)	Dust on windows, tasteless, observed 8.30 a.m.	22
Udimore	(*J. Y. Mair Rumley*)	Seen in gauge on morning of	22
Lewes, Chailey	(*H. S. Hughes*)	Dust fog	21
Burgess Hill	(*F. H. Phillips*)	Chalky rain	26 ?
Heathfield	...	Bullocks would not drink muddy water	No date
Etchingham	("*Daily Mail*")	.....	22
Ticehurst	(*G. J. Courthope*)	In fog afternoon of 20th, none on 22nd so far as seen, but water in gauge muddy on morning of	23
Crowborough Warren	(*H. Ramsbotham in "Globe"*)	Dry during gale	21
Crowborough	(*Mrs. Torswill*)	Sticking to windows	22
S Crowborough	(*J. J. S. Driberg*)	In gauge on mornings of	23, 24
S Wadhurst	(*F. Wilkin*)	Dust noticed on trees in gale at 2.30 p.m.	21
Lamberhurst	(*S. Harmer*)	On returning from church at 12.30 on 22nd found clothes and umbrella splashed with mud	22
Three Bridges	(*D. Bentley*)	Muddy rain water.	
Tunbridge Wells, Steel Cross House	(*J. C. Stenning*)	Dust tasted salt	21
Tunbridge Wells, Boarshead	(*Miss E. Aston*)	Muddy rain	22
East Grinstead ("*Western Daily Mercury*")		.....	

HAMPSHIRE.

Ventnor		Met. Office sunshine card	21, 22
Yarmouth	(*Col. R. P. Crozier*)	Mud on windows, not salt, noticed on morning of	23
Brockenhurst	(*H. O. Wilson*)	Muddy rain on evening of	22
Brockenhurst	(*C. E. Curtis*)	Black coats on Sunday damaged by muddy rain	21-23
Emsworth	(*F. J. Hood*)	In wet mist between 11 and 12 noon with orange light	22
		Also Met. Office sunshine card	21
Ringwood	(*G. B. Corben in "Standard"*)	"A not very copious yellowish rainfall"	22
Southampton	(*A. Farnward*)	.....	
Southampton	...	Met. Office sunshine card	22
Botley	(*Lady Jenkyns*)	Various dates up to	27
Southampton, Highfield	(*Mrs. Silver*)	"Thick yellow cloud between 11 and 12 noon"	22
Fordingbridge	(*Mrs. H. Stevenson*)	.....	
Bitterne	(*Col. F. Welland*)	Peculiar coloured thick mist on 20th and dust seen morning of	21

			Date
Nursling	(*B. de Sales La Terrière*)	Clouds of dust like mist with S.W. wind	21
Bishops Waltham	(*Miss F. Cholmondeley*)	Clouds of dust just before 11 on	21
Swarraton	(*Rev. W. L. W. Eyre*)	"Like pale milk and water" in gauge on morning of	23
Alton	(*F. Mangles*)	21st, wind with curious mist like driving rain, windows dirty on morning of 23rd	21-23
Andover	(*H. Peniston*)	Muddy rain	?22
Farnham, Warren Corner	(*F. Wilkin*)	.....	22
Hartford Bridge	("*Daily Mail*")		

BERKSHIRE.

Wokingham	(*H. C. Mylne*)	Air dusty on 20th and 21st, milky opaque rain in gauge morning of 23rd, also on 26th and 27th	20, 21, 23, 26, 27
Ashbury	(*R. Pound in "Standard"*)	Rain about 9 a.m. of dirty milky colour	22
Wantage	(*F. Fraser*)	Dust storm threatened on Saturday, milky rain early on	22
S Lockinge	(*C. H. Eady*)	"Almost impossible to see through windows"	22
Denchworth	(*Rev. W. O. Wait in "Standard"*)	Dust due to pollen	22

HERTFORDSHIRE.

New Barnet	(*H. E. Freir*)	.....	22
Watford, Russells	(*Mrs. Evans*)	Yellow haze on 21st, dust seen on windows	22
Welwyn	(*J. H. Fitt*)	Muddy shower about noon	22

BUCKINGHAMSHIRE.

Slough	(*Col. M. F. Ward*)	Rain a sort of grey colour on morning of	23, 24, 25
Stoke Poges	(*Mrs. H. Stevenson*)	Dry haze and dust on windows	21
Bulbourne	(*T. E. Beasley*)	.....	
Addington Manor	(*J. Mathison*)	Remarkable haze, specially about 11 a.m.	21
Bletchley	(*Rev. F. M. Higgins*)	Reddish dust on windows about	20 or 21

OXFORDSHIRE.

Henley	(*Rev. F. R. Harnett*)	Nothing peculiar in gauge, but water in tank muddy	23
Culham	(*J. S. Davis*)	Windows dirtied	24
Banbury	(*Lt.-Col. A. G. England*)	Dust on cucumber frames morning of	23

NORTHAMPTONSHIRE.

Wellingborough	(*Miss H. E. Sharman*)	Yellow haze and very dirty windows	22

BEDFORDSHIRE.

Hulcote	(*Rev. R. C. F. Scott*)	Windows cleaned day before, dirty on	22

ESSEX.

Romford	(*G. P. Hope*)	.....	21
Havering	(*G. P. Hope*)	Grey dust on W. and S.W. side of trees	21

			Date
Brownings, near Chelmsford	(*W. W. Duffield*)	.....	
Witham Terling	(*C. Richardson*)	Trees and bushes thick with red grey dust.	21
East Bergholt	...	Haze and dust	21
Dovercourt	(*Mrs. Mathew*)	.....	

SUFFOLK.

Ipswich	(*Mrs. Willimott*)	Few drops of muddy rain at 10.35 a.m.	22
Clare, Stansfield	(*Rev. J. R. Little in "Standard"*)	Yellow haze 21st, drizzle 22nd, and mud on morning of	23
Hawkedon Rectory	(*Rev. B. P. Oakes*)	Smoky haze	21
Fritton, near Yarmouth	(*Miss J. E. Cubitt*)	Haze on 21st, heavy squall between 7 and 8 p.m., mud on frames on morning of	22

NORFOLK.

Dereham	(*C. A. Hamond*)	Haziness and dust in showers	21
Wroxham	(*W. F. Green*)	Dirty windows	22

WILTSHIRE.

Donhead St. Mary	...	Muddy rain and milky water-butts	22
Salisbury	(*H. Peniston*)	Dirty windows	Uncertain
S Westbury	(*Rev. S. Dugdale*)	Noticed in raingauge	Uncertain
Market Lavington	(*Miss G. Bouverie*)	.....	22

DORSET.

S Portland	(*J. M. Head*)	Deposited on windows during morning	22
Swanage	(*A. E. Brunsden in "Evening News"*)	Fog and haze on 22nd, salmon-coloured deposit on morning of	23
Wareham	(*A. H. Bloomfield*)	Dust fell on 21st, muddy rain	22
Dorchester	(*Rev. S. E. V. Filleul*)	Yellow fog, windows dirty	24
Bridport	...	.....	
Beaminster	(*J. S. Kitson*)	Water from N. roof of a house clear, from S. roof muddy	21, 22
Wimborne	(*J. P. Moss*)	Also on a N. window	22
Blandford	(*Mrs. Crofton*)	Windows reddened with muddy rain early on	21

DEVONSHIRE.

S Brixton	(*Miss F. S. Collinsplatt*)	Probably fell on 21st, seen on morning of	22
Plymouth	...	Met. Office sunshine card	20, ?21, 22, 23, 24
Plymouth	("*Daily Express*")	.....	
Stoke Damerel, Devonport	(*Miss Metham*)	.....	22
S Ivybridge	(*M. A. Glanville*)	Fell in a thick yellow fog between 8 and 9 a.m.	22
Plympton	(*J. Walling in "Western Morning News"*)	Fell in yellow fog between 7 and 8.30 a.m.	22
S Plympton	(*J. Cowram*)	Fell in yellow fog between 7 and 8.30 a.m.	22
Delamore	(*Miss Glanville*)	.....	22
South Brent	(*W. L. Fox*)	.....	
Bere Ferrers	(*Rev. F. Wintle per Rev. H. A. Boys*)	Fell in yellow fog between 7 and 9 a.m.	22
Torquay	(*E. F. Baynes*)	.....	22
Torquay	(*A. G. Manley in "Western Morning News"*)	Yellow deposit seen on morning of	23

				Date
	Staverton	("*Western Morning News*")	.....	22
	Buckfastleigh	(*R. A. Earp in "Nature"*)	Between 10 a.m. and noon on	22
	Ipplepen near Newton Abbot	(*per Miss E. H. Pocklington*)	In fog between 7 and 8 a.m.	22
	Ashburton	("*North Devon Herald*")	.....	
	Newton Abbot	(*W. G. Aspland*)	A white clayey powder	22
	Newton Abbot	(*J. H. A. H. in "Standard"*)	Rain quite brown	22
	Newton Abbot	(*D. W. Crawford*)	Rain colour of pea soup	21, 22
	Teignmouth	*J. B. B. in "Western Morning News"*)	.....	22
S	Tavistock, Whitchurch	(*E. E. Glyde*)	.....	22
	Dawlish	(*Miss Collis*)	Thick foggy rain, and yellow light between 8 and 9 a.m.	22
	Dawlish	(*E. Cozens in "Standard"*)	Colour of white fire-brick	22
	Marystowe	(*The Vicar in "Western Morning News"*)	.....	22
	Sidmouth	(*Mrs. Stanford*)	Windows very dirty on two days	18, 19, or 19, 20
S	Rousdon	(*C. Grover*)	Morning of	22
	Tiverton	(*J. W. Wetherell in "Western Daily Mercury"*)	.....	
	Torrington	(*Yeoman in "Western Morning News"*)	Morning of	22
	Torrington, Little Silver	(*F. A. Barton in "Globe"*)	Chalky looking	22
S	Fremington	(*T. Wainwright*)	In lurid mist between 9 and 9.30 a.m.	22
	Arlington Court	(*Lady Chichester in "Times"*)	Morning of	22
S	Lynmouth	(*J. H. Mead Briggs*)	Found in gauge on morning of	23

CORNWALL.

	Lizard	("*North Devon Herald*")	.....	
	Penzance	(*G. P. Hope*)	Yellow mist	21
	Falmouth	(*W. L. Fox*)	Yellow dust (and worms on 25th)	22
	Falmouth	...	Met. Office sunshine card	21, 22, 23
	Ponsanooth	(*Newspaper cutting*)	.....	22
	Scorrier	(*E. H. Williams*)	"Heavier and redder than in 1902"	22
	Newquay	...	Met. Office sunshine card 20 (?)	21, 22
	Merrymeet	(*Mrs. Hammond*)	.....	22
	Menheniot	,,	Yellow fog and red dust at 8.30 a.m.	22
	Liskeard	(*L. C. Foster*)	.....	22
	Pentillie Castle	...	Yellow haze between 7 and 8 a.m., and rain at 9.45, formed red puddles	22
	Gunnislake	(*Newspaper cutting*)	.....	22
	Altarnon	(*C. U. Tripp*)	.....	22
	Trewint	,,	.....	22

SOMERSET.

	Milverton	(*Miss Bere*)	Morning of	27
	Belmont, near Bristol	(*Miss A. Fry*)	.....	Date uncertain

GLOUCESTERSHIRE.

	Avonmouth	(*W. W. Squire*)	Dust deposited on lighthouse	22
	Cirencester	(*Miss Stanton*)	Between 9 and noon	22
	Cirencester	(*G. S. L. Mildmay*)	.....	Date uncertain
	Cirencester	(*C. P. Hooker*)	Rain-water tanks seen turbid on	23
	Cirencester	(*W. J. Stanton*)	About 9 a.m.	22
	Lydney	(*W. N. Meredith*)	.....	22

			Date
Lydney	(*Dr. H. Cook*)	In raingauge on morning of	23
Stonehouse	(*E. Jackson*)	All rain-water spoilt	21
Forest of Dean	(*P. Baylis*)	Water-butts muddy over a large area	23
Cranham	(*Miss H. Organ*)	Rain-water muddy	22
Great Witcombe	,,	,,	22
Gloucester, Brockworth	,,	Dust on windows	22
Ruardean	(*E. T. Burton*)	Rain a reddish-brown colour	22
Langleaves, near Gloucester	(*Hy. T. Perlis*)	Trees dusty on 21st; muddy rain, 22nd	21, 22
Gloucester	(*G. H. Whittaker*)	Muddy rain night of 20th, morning of	21
Cheltenham	(*Mrs. W. Griffiths*)	Muddy windows	21
Beckford Tewkesbury	(*F. Slade*)	Discoloured rain on Sunday afternoon	21

HEREFORDSHIRE.

Dilwyn	(*T. L. Hall*)	Dirty rain-water morning of	22
Kington	(*S. Robinson*)	Muddy rain-water	22

SHROPSHIRE.

Ludlow	(*Rev. R. P. Dansey*)	Discoloured rain	22
Nantmawr	("*Daily Telegraph*")	Rain like lime-water.	
Petton	(*Newspaper cutting*)	.....	
Oswestry	(*C. Kempster in "Globe"*)	Muddy rain, morning	22

WORCESTERSHIRE.

Malvern	(*F. Shelmerdine*)	.....	Date uncertain.

LEICESTERSHIRE.

Leicester	(*H. Ellis*)	Dirty windows.	

CHESHIRE.

Doddleston Rectory	(*Rev. A. C. Gordon*)	Dirty rain	27

YORKSHIRE.

Bridlington	(*Mrs. Gunton*)	Dust on railings	25

MONMOUTH.

Caerleon	(*F. J. Mitchell*)	Thick rain.	
Wentwood Water Works	(*T. D. Evans*)	Rain-water, milky	22-24
S Llanfrechfa Grange	(*F. J. Mitchell*)	Thick water, like lime-water	22-24
Usk	(*Rev. R. P. Dansey*)	.....	22
Abersychan	(*A. J. Cooke*)	Kind of red gravel	22
Abertillery	("*Western Mail*")	Deep clay colour.	
Monmouth	...	Whitish-yellow sand	22
Llanvihangel Court	(*Miss Sturt*)	.....	23
Llantilio Court	(*F. Allaker, at request of Sir H. M. Jackson*)	Cloudy water-butts, colour of soapy water	22

GLAMORGAN.

Barry	(*A. Mee in "Western Mail"*)	.....	22
Llantwit Major	("*Western Mail*")	.....	22
Dinas Powis	("*S. Wales Daily News*")	Pink rain	22
Porthcawl	("*Western Mail*")	.....	22
Pencoed	("*S. Wales Daily News*")	.....	24
Port Talbot	...	Met. Office sunshine card	22

			Date
Treharris	(*B. S. Evans*)	Coloured rain, 9.30 a.m.	22
Swansea	("*Western Mail*")	Muddy rain; so dark lights required till 10 a.m.	22
Neath	(*Major Green*)	Muddy rain, 11 a.m.	22
Pontardulais	(*E. Davies*)	Muddy rain-water and dirty windows	22
Ammanford	("*Western Mail*")	.....	23, 24

CARMARTHEN.

Kidwelly	("*S. Wales Daily News*")	Buff-coloured rain	22
Laugharne	("*S. Wales Daily News*")	Yellowish-brown sky at sunrise, muddy rain in morning	22
St. Clears	(*E. Howell*)	Slight dust morning 21st, rain-water salt	22
S Whitland	(*R. A. Higginbottom*)	Sediment in rain.	22
Llandilo	("*S. Wales Daily News*")	Yellow rain between 9 and 10 a.m.	22
14 Miles N. of Neath	(*Major Green*)	Roof-water too muddy for horses to drink	22
Llandovery	(*J. H. Perkins*)	Heavy shower 9 a.m. yielding muddy rain	22

PEMBROKESHIRE.

Tenby	(*H. Ellis*)	.....	22
St. Ann's Head	...	Met. Office sunshine card	21, 22
Portfield, near Haverfordwest	(*J. H. Phillips*)	Muddy rain between 6 and 9 a.m.	22
Haverfordwest	,,	,, ,, ,,	22
Clynderwen	("*Western Mail*")	,, ,, 7 and 8 a.m.	22
Treffgarne Hall	(*Col. Lloyd*)	Red colour in rain	27
Newport	("*S. Wales Daily News*")	Yellowish mist and thick rain	22

CARDIGANSHIRE.

S	St. Dogmaels	(*David James*)	Sediment in rain-water.	22

BRECONSHIRE.

Crickhowell	("*Western Mail*")	Yellow rain, morning of	22
Devynock	(*Mrs. Davies*)	Muddy rain afternoon of 21st, and yellow dust morning of 22nd	21, 22

RADNORSHIRE.

Llandrindod Wells	(*Dr. W. B. Davies*)	Muddy rain	22

MONTGOMERYSHIRE.

Llanfair, near Welshpool	(*Capt. A. B. Drummond*)	Muddy rain	22
Llanfyllyn	,,	,,	22
,,	(*J. M. Dugdale*)	,,	22
Llansantffraid, near Oswestry	(*Capt. A. B. Drummond*)	,,	22
Llangynog	,,	,,	22

DENBIGHSHIRE.

Llangedwyn	(*Capt. A. B. Drummond*)	Muddy rain	22
Llanrhaiadr	,,	,,	22

MERIONETH.

Corris, 15 Miles S. of Llanbedr	(*H. G. Hollingworth*)	Black dust	22
S Dinas Mawddy	(*E. D. Jones in "Manchester Guardian"*)	Discoloured rain	22
Llanbedr	(*H. G. Hollingworth*)	.....	

			Date
CARNARVON.			
Belan Fort . .	(*Hon. F. G. Wynne*)	.....	Date uncertain.
ISLES OF SCILLY.			
St. Mary's . .	...	Met. Office sunshine card .	20, 21, 22
JERSEY.			
St. Helier . .	(*Rev. M. Dechevrens*)	Coloured fog on 21st and 22nd, but no dust	21, 22
GUERNSEY.			
St. Martin's .	(*B. T. Rowswell*)	Muddy rain morning of . .	22
St. Pierre du Bois	(*J. J. Carey*)	Muddy rain.	22
CAVAN.			
Cavan . . .	(*R. G. E. Flower*)	Few drops of muddy rain . .	22

(Where no date is mentioned there is reason to believe that the fall occurred between the 20th and 23rd.)

Observations from the Atlantic Ocean and Africa.

From the *Monthly Pilot Charts of the North Atlantic*, for April and May 1903.

S.S. *Bornü.* 27° N., 15°½ W. February 19. Heavy sand-storm (*Nature*, vol. lxvii. p. 420).

S.S. *Sekondi.* During a voyage from the Canaries to the Gulf of Guinea and back, between December 28, 1902, and February 27, 1903. Experienced repeated falls of sand.

S.S. *Kinfauns Castle.* From 6° N., 14° W. to 18° N., 18° W. February 27 to March 1. Falls of fine red sand.

S.S. *Matatua.* 4° N., 25°½ W. to 12° N., 23° W. February 12-14. Considerable sand haze. 25° N., 19° W. to Grand Canary. Dense sand-storm.

S.S. *Abertay.* 40° N., 23°½ W. February 21. Fine light-reddish dust (*Shipping Gazette* for March 13).

S.S. *Pembroke Castle.* 36° N., 13° W. to 3° N., 14° W. February 18-26. Continual sand-storms.

R.M.S. *Briton.* 48 miles S., 25° W. of Tenerife. February 18, 10 a.m.

S.S. *Kirkby.* 33°½ N., 22° W. to 30° W. February 20-22.

R.M.S. *Tagus.* Left Southampton for Barbados on February 18, and "for three days whilst in mid-Atlantic" fell in with a quantity of red dust. Position and dates not given.

S.S. *Dunolly Castle.* 13° N. to Las Palmas. Sand-storm of three days' duration.

S.S. *Sokoto.* Tremendous sand-storms for eight days off the West Coast of Africa.

From *Correspondence.*

H.M.S. *Prometheus.* 46½° N., 12° W. Night of February 20.

Steam-dredger *Mexico.* 200 miles W. of Madeira. Afternoon of February 20.

From the *Comptes Rendus.*

S.S. *Ville de San Nicolas.* 11° N., 27° W. to 12° N., 26° W. February 22, 23.

S.S. *La Cordillère.* 13° N., 21° W. to 14° N., 20° W. February 21.
S.S. *Caravellas.* 22° N., 21° W. to 26° N., 19° W. February 19, 3 a.m., and subsequent days.

Information supplied by the courtesy of the Deutsche Seewarte, Hamburg (received through the Meteorological Office).

S.S. *Numidia.* 23° N., 21°½ W. to 24°½ N., 21° W. February 20.
S.S. *Roland.* 25° N., 16° W. February 19.
S.S. *Tijuca.* 8° N., 27° W. February 23.
S.S. *Wittekind.* 4° N., 27° W. to 15° N., 21° W. February 23-26.
S.S. *Erlangen.* 7° N., 28° W. to 15° N. 25° W. February 23-25.
Potosi. 6° N., 29° W., and 9° N., 32° W. February 22, 23.
Carl. 39° N., 26° W. to 42° N., 22° W. February 19-21.
S.S. *Markomannia.* 22° N., 22° W. to 24° N., 21° W. February 20, 21.
S.S. *Holsatia.* 28° N., 19° W. to 20° N., 28° W. February 19-23.
S.S. *Sparta.* 25°½ N., 23°½ W. to 28° N., 21°½ W. February 20, 21.
S.S. *Nubia.* Between Gibraltar and Algiers. February 21.
S.S. *Crefeld.* 31° N., 18° W. February 19.

From *Annalen der Hydrographie und Maritimen Meteorologie*, October 1903.

S.S. *Frisia.* 36° N., 26°½ W. February 20.
S. *Pampa.* 48° N., 13° W. February 22.

From the *Algerian Weather Report* for February 18.

Sand-storm at Laghouat and Ouarqla.

AZORES.

From *Monthly Pilot Chart* for May 1903.

Ponta Delgada. February 20. A heavy fog appeared in the morning, and fine yellow dust fell, covering walls, vegetation, and animals. On February 22 the snow on Mount Pico (7467 feet), was found to have a yellowish tinge.

From *Annalen der Hydrographie und Maritimen Meteorologie*, October 1903.

Santa Maria. February 20, 21.
Terceira. February 21.
Graciosa. ,,
S. Jorge. ,,
Pico. ,,
Fayal. ,,

Tenerife (*Meteorologische Zeitschrift*, 1903, page 134). February 19.

DISCUSSION.

Mr. R. H. CURTIS said he had observed in London on Saturday, February 21, from about midday, a thick haze, which was the more remarkable because of the strong Westerly wind which was blowing at the same time. The haze continued for some hours, and was as dense in the neighbourhood of Leatherhead in Surrey, where he went in the course of the afternoon, as it had been in London; before 9 p.m., however, it had quite vanished, and the evening was very clear. When at a later date he was examining some sunshine cards for

February received from various parts of the country, he was struck by the fact that many of them were stained, and had a yellowish-brown deposit upon them. That cards from places so widely separated as the Scilly Islands and Dungeness should be similarly stained was in itself remarkable ; but the coincidence of the date of its occurrence with that on which the haze had been observed in London suggested some possible connection between the latter phenomenon and the cause of the staining on the cards, and led him to look carefully for all cards which were similarly discoloured, and to examine them with a fairly powerful lens. In many cases, where the staining had been most considerable, the observer, regarding it as a disfigurement of the card, had tried to remove it ; but although this had no doubt been the means of removing from the card a good deal of the solid matter, it fortunately had not done so altogether, and had seldom got rid of much, or any, of the stain the deposit had made. One noticeable feature was that the deposit had generally been made on the eastern side of the bowl which held the card, a result of the Westerly wind with which the deposit had arrived. At nearly every place along the southern counties of England from which cards were received and examined, as well as at Jersey, the evidence of its deposit was unmistakable, and in several instances it was shown upon the cards for more than one day. At Scilly, and at a few other places in the extreme west, there was evidence of it on the cards for February 20, but this might possibly have been deposited during the night of 20-21 ; and also it is just possible that the stains on the cards for days subsequent to 21 may have been caused by a residue of the deposit having been left in the bowl after the card for 21 had been withdrawn. North of Leicestershire the evidence of the dust-fall, although not entirely absent, was less frequent and also less absolute, partly because the cards available are from places more widely separated ; partly also because most of them are more or less in the neighbourhood of large towns, and evidence of the presence of the dust in question would be very likely to become obscured by stains made by matter produced much nearer home ; but also without doubt because, as has been pointed out in the paper, the course of the main stream of air carrying the dust did not traverse that region. But Mr. Curtis thought there was conclusive evidence that some of the dust did fall, perhaps sporadically, at certain places much further north. At Marchmont in Berwickshire, it was unmistakable, as it was also at Stornoway. In the Isle of Man there were faint indications of it ; but at one or two places on the north-west coast of England from which cards had been received and examined no trace of the deposit had been left. At Kingstown, and at Parsonstown, in Ireland, there were slight but apparently real traces shown ; and the letter from Cavan which Dr. Mill had read was corroborative that the deposit had fallen in parts of Ireland.

Although attention had only recently been called to the fall of these deposits of sand, Mr. Curtis thought it probable that they were really of more frequent occurrence than had been supposed, and that it had been due to lack of combined observation that the phenomenon had generally passed unrecorded. It was not improbable that a new function awaited the sunshine recorder in recording also falls of dust when these occurred under conditions which would enable the dust to adhere to the cards. In the gale of wind which occurred on February 27 last the card which was exposed in the recorder at Blackpool, a mile or more from the sea, behind the town, was found to be thickly encrusted with both sand and salt, carried there by the wind, the deposit being again on the eastern half of the card and the wind Westerly. The lens of the instrument was also so thickly encrusted with salt and grit that although the sun shone brightly for four-and-a-half hours, not the faintest trace of a burn was made on the card.

THE PRESIDENT (Capt. D. WILSON-BARKER) remarked that Dr. Mill had followed up previous investigations in dust-fall phenomena, and with the aid of Mr. Lempfert's wind maps and trajectories, had read a most interesting and valuable paper. It was certain that our knowledge of the movements of the air in cyclonic disturbances would be much increased by such investigations. At a former meeting Dr. Shaw had dealt very lucidly and thoroughly with the subject, and in the United States it was receiving considerable attention. Observers would do well to make sure that they were not misled as to the nature of the dust observed. The wind had remarkable power of transporting dust of considerable density to great distances, but a purely local dust might easily be confused with another sort. At Greenhithe, for instance, in certain rare conditions of the wind, his ship would be covered with extremely fine clinkers of burnt coal dust, which undoubtedly came from the furnaces of cement works in the neighbourhood. It often happened at sea that a layer of dust appeared to cover the surface of the ocean, but on examination this dust proved to be a minute sea-weed instead of the coal dust it resembled. The very cordial thanks of the Society were due to the authors of this most interesting paper.

Mr. F. DRUCE said that it might possibly be of interest to know that his observer in the Surrey Hills reported a fall of deposit on Friday, February 20, and that upon further enquiry this was found to be correct, and that certainly a fall had occurred either on the evening of the 20th or morning of the 21st—an earlier date than the one under discussion. There was, however, no discolouration of the water in the rain-gauge on the 21st, but on the 22nd discolouration had taken place. Doubtless a different current of air might have deposited the dust a day or two earlier in this part of the country.

Mr. F. J. BRODIE fully concurred in the remarks of previous speakers as to the value and interest of the paper. Dr. Mill had given an excellent account of the nature and extent of the deposit, and Mr. Lempfert had clearly shown that the air currents prevailing at the time were favourable for the transmission of dust particles from a region as distant as the Sahara desert. With regard to the origin of the fall there could, in fact, be very little doubt. "Origin" and "cause" were, however, by no means synonymous terms. The phenomenon itself was admittedly very unusual, but could as much be said with regard to the atmospherical conditions under which it had occurred, so far as they were presented by Mr. Lempfert's charts? He (Mr. Brodie) would venture to say that it would not be difficult to find dozens, or even scores, of cases in which the pressure distribution over Europe and the Atlantic was practically identical with that observed in February last, but in which no record of any dust-fall was obtainable in these islands. One could only surmise that in the case under discussion the African deserts were visited by a cyclonic storm of more than ordinary intensity, and that unusually large quantities of dust were whirled up into the higher regions of the atmosphere. In the central parts of Northern Africa meteorological observations are, however, extremely scarce, so that the existence of such a storm could not be clearly proved.

Mr. C. HARDING remarked that the charts of February 17-18 pointed to low pressure and decided disturbance over the north-western part of Africa, and that it was well known that great quantities of dust were whipped up and carried great distances during cyclonic disturbances. That this had happened in the present instance is proved, as it was easily traceable by the vessels to our own shores. The *Pembroke Castle*, mentioned by Mr. Lempfert for one: "And the hazy effect produced by this dust, had caused many vessels to be delayed in their course." This would tend to show that a large proportion of it must have been due to the low temperature at the time. Mr. Lempfert had perhaps only started his trajectories a little too late—they should possibly have started about the 18th or 19th. Mr. Harding's daughter, living in a quiet part of Sussex,

had told him that on Sunday, February 22, the windows of her house were covered so thickly with a fine deposit as to obscure the light. He would suggest that the emphasised influence of the Polar Current on the north produced the low temperature in the north of the British Isles, and the Gulf Stream produced warmth on the southern side.

Dr. H. R. MILL agreed with Mr. Brodie that it would be very satisfactory to discover the causes of these phenomena, and thought that the only way to do so was by obtaining successive approximations, by making the most of all the evidence that could be brought forward from time to time, and this was what was being done. It was, however, difficult to obtain information on the subject, as at present no recognised methods for dealing with such falls existed. Three successive Springs had brought dust-falls with them to Europe, and it might be that the phenomenon was a very common one, perhaps even of annual occurrence. The occurrence of wind-borne dust off the Sahara coast was so common that the name of "Sea of Darkness" had been given to that part of the ocean from the frequent dust-fogs. The whole subject had been handled comprehensively by Ehrenberg in his *Passatstaub und Blutregen* ("Trade-wind Dust and Blood-rain") as long ago as 1847. Last year Capt. Hepworth had published a warning to mariners against these dust-storms. The storms carried from the Sahara at least as far as Tenerife were only normal, but were abnormal when carried as far as in the case now under discussion. The wider extension was probably due to unusual barometric movements.

That the dust was sometimes blown over to our islands, and sometimes not, was probably due to the distribution of pressure; and in all cases of an anti-cyclone resting over the south-west portion of Europe, he would like to see whether some evidence of dust-fall was not forthcoming. In conclusion, he would like to say that he thought Mr. Lempfert's part in the preparation of the paper was by far the more important, for it applied the method of air-trajectories to the elucidation of a particular problem with a very satisfactory result.

Mr. R. G. K. LEMPFERT, in discussing the question of the dust deposits on the cards of sunshine-recorders, observed that Dr. Flett's investigations had shown that the deposit invariably contained much matter of undoubtedly local origin, and therefore it must be regarded as possible that in some cases the deposit might be entirely of local origin. It was therefore necessary to regard reports from isolated places, far removed from the main area of deposit, with much scepticism, unless indeed microscopic examination by an expert placed it beyond doubt that the extremely fine red clay, recognised by Dr. Flett as the part of all the deposits which was probably of foreign origin, was present.

In answer to Mr. Brodie's query as to the primary cause which raised such vast quantities of dust into the atmosphere, he pointed out that the Algerian Daily Weather Report for February 18 records strong winds and gales in the north of Africa, which seem to show a cyclonic circulation round a centre of low pressure situated south-east of Algeria. Dr. Herrmann had so interpreted them on the maps published in his paper.

Climatology of St. Helena.—The only meteorological station in St. Helena is placed about 1900 feet above sea-level, and records are taken only once a day. The total rainfall for the year past was 34·74 ins.—nearly 4 ins. below that of the previous year. Rain fell on 254 days, but the greatest fall in one day did not exceed 1·41 ins. June, July, and August are the wettest months. The prevailing wind ranges from East-south-east to South-east, and on only seven days was it recorded as calm. The highest maximum shade temperature was 78°, on February 6; the lowest minimum 62°, on September 1.—*Geographical Journal*, November 1903.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 18, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

HENRY L. ATTRIDGE, Oldfield Road, Sea Point, Cape Town ;
Rev. DANIEL CROSS BATES, Wellington, New Zealand ;
CHARLES LOWTHIAN BELL, Linthorpe, Middlesborough ;
WALTER CLEEVE EDWARDS, Assoc. M.Inst.C.E., Port Elizabeth, Cape Colony ;
Capt. ROBERT FORD, 13 St. George's Road, Hull ;
ROBERT VALPY FULTON, M.B., Dunedin, New Zealand ;
T. MERTHYR GUEST, J.P., D.L., Inwood, Henstridge, Somerset ;
ROBERT T. A. INNES, F.R.A.S., Meteorological Department, Johannesburg ;
THOMAS NICHOLAS LESLIE, F.G.S., Vereeniging, South Africa ;
Capt. CUTHBERT H. LEY, R.E., Trigonometrical Survey, Pretoria, Transvaal ;
JAMES DOUGLAS MACDONOGH, L.R.C.P.I., Bettws-y-Coed, North Wales ;
ENOCH MATHER, M.D., LL.D., Detroit, Michigan, U.S.A. ;
WILLIAM MORRIS, M.Inst.C.E., Kent Waterworks, Deptford ;
GEORGE EDWIN JAMES ROSE, Wuhu, China ;
Capt. WILLIAM RICHARD ROWE, Grassendale, Liverpool ; and
Capt. LEWIS H. TAMPLIN, Wuhu, China,

were balloted for and elected Fellows of the Society.

The following communication was read :—

"THE GREAT DUST-FALL OF FEBRUARY 21 AND 22, 1903, AND ITS ORIGIN." By HUGH ROBERT MILL, D.Sc., LL.D., F.R.Met.Soc., and R. G. K. LEMPFERT, M.A. (p. 57).

December 16, 1903.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

CHARLIE OWEN BAINES, Burlington Crescent, Goole ;
JOHN NATHANIEL BEADLES, 27 Mecklenburg Square, W.C. ;
REGINALD BROWN, Assoc. M.Inst.C.E., Public Offices, Southall ;
FREDERICK JAMES FINGLAH, Borough Surveyor, Carmarthen ;
VINCENT SMITH, Town Hall, Teignmouth ;
JOHN HENRY TAYLOR, M.Inst.C.E., Jordan Hill, Barnsley ;
THOMAS GEORGE TAYLOR, Borough Engineer, Ramsgate ;
THOMAS JAMES THOMAS, Assoc. M.Inst.C.E., Ebbw Vale, Monmouthshire ; and
CHARLES THOMSON REES WILSON, M.A., F.R.S., Sidney Sussex College, Cambridge,

were balloted for and duly elected Fellows of the Society.

Mr. D. W. HORNER and Mr. T. P. NEWMAN were appointed Auditors of the Society's Accounts.

The following communications were read :—

1. "SOME ACCOUNT OF THE METEOROLOGICAL WORK OF THE LATE JAMES GLAISHER, F.R.S." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 1).

2. "ON CERTAIN RELATIONSHIPS BETWEEN THE DIURNAL CURVES OF BAROMETRIC PRESSURE AND VAPOUR TENSION AT KIMBERLEY, SOUTH AFRICA." By J. R. SUTTON, M.A., F.R.Met.Soc. (p. 41).

CORRESPONDENCE AND NOTES.

Explosive Lightning.—Capt. Hepworth, the Marine Superintendent of the Meteorological Office, has forwarded the following extract from a log recently received at that Office :—

"On the evening of Wednesday, the 25th inst., during a heavy hail squall with heavy thunder and lightning, a whizzing sound as if a rocket had been discharged, which lasted about a second, then a sharp crack and a very loud report burst. Some of the fire was of an intense deep red, and smaller sections of a very bright yellow, which fell into the sea apparently not more than 150 yards from the ship. About one and a half minutes later another explosion of the like nature followed, and then two terrific claps of thunder which were deafening. The hail squall lasted about 15 minutes. The ship was off the Ameland Light on the Dutch coast, distant about 17 miles."—WM. BUTLIN, 2nd mate, ss. *Varna*, Millwall Dock, London, November 28, 1903.

Climate of Caupolican Bolivia.—The *Geographical Journal* for December contains an account of an Expedition to Caupolican Bolivia, 1901-1902, by Dr. J. W. Evans. He gives the following description of the climate :—"The seasons are not so well marked as in other tropical countries I have visited. There is no real dry season such as is experienced in India and South-West Brazil, and the distribution of the rainfall varies considerably from year to year, and from point to point. I crossed the Cordillera Real early in September in a slight snowstorm. It rained the greater part of the succeeding day on the upper part of the north-eastern slopes of the Cordillera. During the rest of the month rain only fell on one day, but on many occasions the sky was threatening, and rain must have fallen on the adjoining heights. In October, which was mainly spent in the valley of the Rio Caca, rain frequently fell, the total amounting to about 9·2 ins., falling on sixteen different days. In November, at San Buena Ventura, just beyond the outside limit of the mountains, the total rainfall was 13·5 ins., distributed over eleven days. In December it rained eight or nine days, on several occasions very heavily. The total for the month was probably about the same as for November. In January, in the Tuiche valley, it rained on eleven or twelve days, on five occasions heavily. In February, on the way to Apolo and at that place, it rained on ten or eleven days, often very heavily. In March, 6 ins. fell—in fifteen days—at Apolo. In April, at Apolo and on the road to Pelechuco, it rained on ten or eleven days, about 5 ins. falling. In the first ten days of May it rained or snowed, near Pelechuco, and on the road to Juliaca, on three or four days. In June, on the way from Sorata to the Beni, it rained on seven or eight days. In the low country, in July, August, and September, occasional heavy showers occurred. It will thus be seen that no month is completely free from rain, and that from October to April there is a heavy but never continuous fall. The actual amount, however, varies, as we have seen, from valley to valley and in different parts of the same valley, and diminishes, though in an irregular manner, as we

pass from the Cordillera to the plains. Several days of rain may occur on the south-west side of the Bala-Susi range, while it is quite dry in the plains.

"To the north-east of the Cordillera the prevalent winds are South-east and North-west. The frequency of the latter wind appears to become greater as the distance from the Cordillera increases. Everywhere to the north-east of the Cordillera the South-east wind brings cold, cloudy, and usually rainy weather. It is generally preceded by a period of low atmospheric pressure, but its arrival is accompanied or even heralded by a sharp rise in the barometer. In the plains this wind is known as the "Sur" or "Surazo." It often sets in with great violence, and the rain is sometimes followed by a period of cold dry weather. In Caupolican, when winds are light, they often blow from the South-east in the morning and the North-west in the evening. When the days are overcast, the sky sometimes clears for a short time soon after sunset, but soon clouds over again.

"There is a general correspondence between the movements of the barometer at La Paz and in the plains—that is, a wave of high or low pressure affects both, but the resulting weather is widely different.

"The temperature throughout the region I have been describing is much lower than might have been expected from the latitude and altitude."

Rainfall at Jerusalem and Hebron.—The *Quarterly Statement of the Palestine Exploration Fund*, 1902, has a paper (in fact his *last* paper) by the late James Glaisher, F.R.S., on the "Rainfall at Jerusalem in the 41 Years 1861-1901." The observations were made by Dr. Chaplin from 1861 to 1882, and since 1883 they have been continued under the auspices of the Fund.

The yearly totals of rainfall and the number of rainy days were as follows :—

Year.	Rainfall. ins.	No. of Days.	Year.	Rainfall. ins.	No. of Days.	Year.	Rainfall. ins.	No. of Days.
1861	27·30	47	1875	27·01	61	1889	13·56	41
1862	21·86	44	1876	14·41	47	1890	35·51	73
1863	26·54	52	1877	26·00	59	1891	34·72	68
1864	15·51	36	1878	32·21	46	1892	31·23	63
1865	18·19	48	1879	18·04	46	1893	30·54	62
1866	18·55	62	1880	32·11	62	1894	35·38	65
1867	29·42	53	1881	16·50	48	1895	23·25	52
1868	29·10	68	1882	26·72	63	1896	32·90	71
1869	18·61	53	1883	31·92	70	1897	41·62	72
1870	13·39	41	1884	23·96	54	1898	28·66	59
1871	23·57	56	1885	29·47	58	1899	22·43	59
1872	20·26	55	1886	31·69	63	1900	21·20	52
1873	22·72	49	1887	29·81	46	1901	17·42	40
1874	29·75	62	1888	37·79	65			

The average rainfall was 25·87 ins., and the number of rainy days 56.

In the *Journal of the Scottish Meteorological Society*, 1903, there is a paper by Mr. A. Watt on the "Climate of Hebron," which deals with the observations made at that place by Dr. A. Peterson from February 1896 to March 1902. The yearly totals of rainfall and number of rainy days for the complete years were as follows :—

	Ins.	Days.		Ins.	Days.
1897	36·79	65	1900	23·80	69
1898	22·57	53	1901	16·25	45
1899	21·49	55			

Bloxam's Smoothing Process.—In the last number of the *Journal of the Scottish Meteorological Society*, Dr. Buchan in his paper on the "Rainfall of Scotland in relation to Sunspots" makes use of the expressions "to bloxam,"

"bloxaming," and "bloxamed," to indicate the method which he has adopted to obtain smoothed mean values. We have not seen these words used before, and think it is to be regretted that Dr. Buchan has coined them. We should much prefer the expressions "to bloxamize," "bloxamizing," and "bloxamized," Unfortunately we have the word "to boycott," but we do not wish to see such expressions multiplied, or we shall have, in the course of time, "to buchan."

It does not appear to be generally known that the particular method of smoothing or averaging was first described and used by Mr. J. C. Bloxam in his *Meteorology of Newport* (1858). He also read a paper on this subject before this Society in March 1862 (*Proceedings*, vol. 1, 143). He there said: "I need not enter here very fully into the nature of the method I advocate, because I have already done this in my published work; but I may describe it shortly. The method is founded on the fact that, in meteorology, the mean of 10 or 11 consecutive days gives more correctly the normal constant value for the middle day of the series, than the middle day itself does; and then the value for every day in the year having been calculated upon this principle, this whole series of amended values can in turn be subjected to the same process; and the process may be reiterated until the daily values are brought to sufficiently regular ascending and descending lines. In the present case the process was twice carried through; and this seems to be all-sufficient for the purpose in view. The special characteristic of the method, perhaps, consists in its combining great *meaning efficiency* with a small range of *meaning action*."

RECENT PUBLICATIONS.

Climate of the Argentine Republic. Compiled from Observations made to the end of the year 1900. By WALTER G. DAVIS, Director of the Argentine Meteorological Office. Ministry of Agriculture, Buenos Aires, 1902. (vi. + 154 pp. and 23 plates.)

The text of this work is the reproduction of the chapter on Climate which appeared in the First Volume of the Second Census of the Argentine Republic (May 10, 1895), published in 1898. The tables, however, have been revised, and include the observations made since the original article was written, up to 1900.

The following is a summary of the heads under which the subject has been dealt with:—

General Outline—

1. Temperature: (*a*) Temperature of the Air; (*b*) Temperature of Evaporation; (*c*) Temperature of the Soil; (*d*) Solar Radiation.
2. Atmospheric Pressure.
3. Humidity of the Air: (*a*) Relative Humidity; (*b*) Pressure of Atmospheric Vapour.
4. Evaporation.
5. State of the Sky: (*a*) Sunshine; (*b*) Clouds.
6. Rainfall: (*a*) Quantity; (*b*) Frequency; (*c*) Thunderstorms; (*d*) Hail.
7. Wind: (*a*) Frequency; (*b*) Mean Direction; (*c*) Velocity.

The text is printed in Spanish and English, and the results are graphically shown by a number of plates.

Indian Meteorological Memoirs. Published under the direction of Sir JOHN ELIOT, F.R.S., Meteorological Reporter to the Government of India. Vols. **14**; **15**, Parts 1 and 2; and **16**, Part 1. Calcutta, 1902-3. 4to.

Vol. **14** (709 pp.) is devoted to the "Rainfall of India." This contains the monthly and annual totals of rainfall at 457 stations in India up to December 1900. The records are for various periods, some commencing in 1844, whilst others begin in 1870. The longest record is that for Madras, 1813-1900. Monthly and yearly averages are also given for the period over which the records extend at each station.

Vol. **15** contains: (1) "Summary and a brief Discussion of Observations of the Clouds recorded at Six Stations in India during the Period 1895-1900," by Sir J. Eliot, F.R.S. (112 pp.). The stations at which the observations were made were Simla, Lahore, Jaipur, Allahabad, Vizagapatam, and Madras. (2) "Report on Cloud Observations and Measurements at Simla, during the Period June 1900 to January 1902," by W. L. Dallas (8 pp.).

Vol. **16**, Part 1, contains: "Monthly Normals of Air Pressure reduced to 32° F. and Constant Gravity, Lat. 45°," by Sir J. Eliot, F.R.S. This gives tables of the atmospheric pressure for each month and year for 121 stations, mostly for the period 1875-1902.

Journal and Proceedings of the Royal Society of New South Wales. Vol. **36**, 1902. Sydney, 1902. (370 + 75 + 52 + 31 pp. and 20 plates.)

This volume contains the following articles:—"The Mitigation of Floods in the Hunter River": by J. H. Marden (25 pp.). This paper discusses the subject from the point of view of the forester.—"Current Papers, No. 7": by H. C. Russell, F.R.S. (10 pp. and 3 pl.).—"Forests considered in their Relation to Rainfall and the Conservation of Moisture" (30 pp.). The following synopsis shows the method of treatment of the subject, which is of considerable importance in New South Wales:—I. Introductory; II. The Historical Method: (*a*) General Observations, (*b*) The case "Forest Destruction *does* diminish the Rainfall, (*c*) The case "Forest Destruction *does not* diminish the Rainfall; III. The Vastness of Rainfall Conditions; IV. Clouds may strike against Trees and deposit Moisture; V. Not merely a Question of Large Trees; VI. Rainfall Measurements in Forest and Open Country; VII. Physiological Action of Trees —Transpiration; VIII. Some Uses of Forests: (*a*) To temper Floods, (*b*) To conserve Springs, and to aid in the more even distribution of Terrestrial Waters, (*c*) To prevent Evaporation of Water, (*d*) To give Shelter to Stock, Crops, etc., (*e*) The Leaves of Forest Trees, etc., afford Manure and Mulch.—"Meteoric Dusts, New South Wales": by Prof. A. Liversidge" (45 pp.).—"The Fallacy of assuming that a Wet Year in England will be followed by a Wet Year in Australia": by H. C. Russell F.R.S. (1 p. and pl.)

Journal of the Scottish Meteorological Society. Third Series. Vol. **12**. Nos. XVIII. and XIX. Edinburgh. 8vo. 209 pp.

In addition to the Meteorological Tables for the two years 1900 and 1901, this contains the following articles:—

1. "The Rainfall of Scotland in Relation to Sunspots," by Dr. Buchan (10 pp. and 11 plates). By "Bloxamizing"[1] Wolf's sunspot relative numbers and also the yearly rainfall for each term of the sunspot cycle for the 44 years 1855-98, Dr. Buchan finds that the results are of a striking character, revealing an intimate connection between the two phenomena; on the one hand, the supra-annual variation of the amounts of the rainfall of Scotland, and, on the

[1] See Note on p. 94.

other, the supra-annual variation of the spots of the sun. The greatest excess in the rainfall, amounting to 7 per cent, occurs during the 7th and 8th terms, after which, on the 9th, 10th, and 11th terms it falls to nearly the average amount.

2. "Meteorology of Christmas Island," by Dr. Buchan (6 pp.). This island is in 10° 25′ S. lat. and 105° 43′ E. long., and is about 200 miles south of the western end of Java. No cyclone has been known yet to have reached it, being outside the cyclone region of the Indian Ocean.

3. "The Climate of Hebron (in Syria)," by A. Watt (19 pp.). (See p. 94.)

4. "Temperature Observations at the Mid-station on Ben Nevis," by T. S. Muir (7 pp.).

5. "Note on Clouds at Fort Augustus," by Rev. C. von Dieckhoff (2 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. September-November 1903. 4to.

The principal articles are:—"Die harmonische Analyse der täglichen Luftbewegung über Hamburg": von Prof. Dr. J. Schneider (13 pp.).—"Wolken und Nephoskope": von L. Besson (12 pp.). This is a discussion of the cloud observations at La Trappe, and the author describes Mons. Teisserenc de Bort's nephoscope, consisting of a horizontal mirror attached to an upright staff with a cross-rod at top, graduated at equal distances. For the full description the paper should be consulted.—"Messungen der Sonnenstrahlung und der nächtlichen Austrahlung, auf dem Sonnblick": von Dr. Felix M. Exner (5 pp.). Angström's pyrheliometer was employed. It appears that frequently an increase in radiation takes place shortly before sunset and after sunrise.—"Über die tägliche Drehung der mittleren Windrichtung auf Berggipfeln von 2-4 *km.* Seehöhe": von J. Hann (11 pp.). This paper is only the first instalment of a critical discussion of Goutereau's paper in the *Annales du Bureau Central Météorologique de France*, 1898. Dr. Hann has calculated the figures from all available mountain stations, and finds that the wind shifts regularly with the sun. We must wait for the continuation of the paper for the final conclusion.—"Die Bewölkung der Schneekoppe": von Max Sassenfeld (7 pp.). This is an interesting discussion of twenty years' cloud observations which well repays study. It is curious to find that the Schneekoppe is covered with cloud for two-thirds of the day—about double as long as is the case at Ben Nevis.—"Referate über russische Forschungen auf dem Gebiete der Meteorologie": von A. Woeikof (8 pp.). This is an interesting account of papers, most of which have appeared in Russian.—"Die Theorie der taglichen Luftdruckschwankung von Margules und die tägliche Oszillation der Luftmassen": von W. Trabert (21 pp.). This is the first part of a criticism of this paper of Margules' on the Diurnal Oscillation of the Barometer, containing a theory already favourably noticed by Hann.—"Über eine doppelte tägliche Periode der Windkomponenten auf den Berggipfeln": von J. Hann (11 pp.). This is a very interesting paper. It is remarkable that Dodabetta exhibits some difference from other mountain stations as to this periodicity.

Report of the Meteorological Council for the Year ending 31*st March* 1902 *to the President and Council of the Royal Society.* London, 1902. 8vo. (163 pp. and 3 pl.)

In addition to the Report for the year, this contains the following appendices:—1. Correspondence with the London County Council with regard to an inquiry into the occurrence and distribution of fogs in London. 2. Statement of provisions for the supply of information to the public. 3. List of captains and officers who have sent in logs classed as "excellent." 4. List of meteoro-

logical logs and documents received from ships. 5. Instruments supplied to the Royal Navy. 6. Instruments supplied to the Mercantile Marine. 7. Report of inspection of stations in connection with the Office, 1901. 8. Storm warning checking. 9. Report on the comparison of the forecasts issued at 8.30 p.m. with the weather subsequently experienced. 10. Conspicuous meteorological occurrences in 1901. 11. Additions to the Library. 12. List of the principal papers printed in the various Reports issued by the Office from the year 1866. 13. Account of receipts and payments for the year ending 31st March 1902.

Philosophical Transactions of the Royal Society of London. Series A. Vol. **202** (pp. 123-141).

This contains "Meteorological Observations obtained by the use of Kites off the West Coast of Scotland, 1902," by W. N. Shaw, Sc.D., F.R.S., and W. H. Dines. This is a discussion of the meteorological records obtained by Mr. Dines during his kite experiments in the neighbourhood of Crinan during the summer of 1902 (see also *Quarterly Journal of the Royal Meteorological Society*, vol. **29**, pp. 65-85).

Results of the Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1900: under the direction of W. H. M. CHRISTIE, C.B., M.A., F.R.S., Astronomer-Royal. London, 1902. (57 + 117 pp.) 4to.

This contains the usual detailed observations made at the Royal Observatory, Greenwich, during the year 1900.

The Horological Journal. Published by the British Horological Institute. London. August to November, 1903. 8vo.

These numbers contain a series of articles on "Sunshine Recorders" by R. Strachan. In addition to the Campbell-Stokes and the Jordan Recorders, descriptions are given of the Recorders by H. M'Leod, J. Maurer, Marvin, Richard Fréres, and W. H. Dines.

Transactions of the Woolhope Naturalists' Field Club, 1902. Hereford. 8vo.

This contains a paper by Mr. H. Southall on the "Weather in Herefordshire during the Nineteenth Century." Many interesting details especially relating to rainfall are given by the author. The months of July 1800 and September 1804 appear to have been rainless. The only other months in the century with less than a tenth of an inch of rain were :—

	ins.		ins.
1826 June	·03	1891 February	·01
1840 March	·05	1895 February	·04
1865 September	·07		

As a contrast to these the following very wet months may be noticed :—

	ins.		ins.
1834 July	7·49	1876 December	7·04
1842 November	7·38	1878 August	7·96
1852 November	9·48	1888 November	8·17
1872 July	7·74		

Water-Supply: A Student's Handbook on the Conditions governing the Selection of Sources and the Distribution of Water. By REGINALD E. MIDDLETON, M.Inst.C.E. London, 1903. 8vo. (168 pp. and 4 plates.)

This treatise on waterworks engineering has been written specially for engineering students, and sets forth in a compact manner the general scientific principles upon which the subject is based.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

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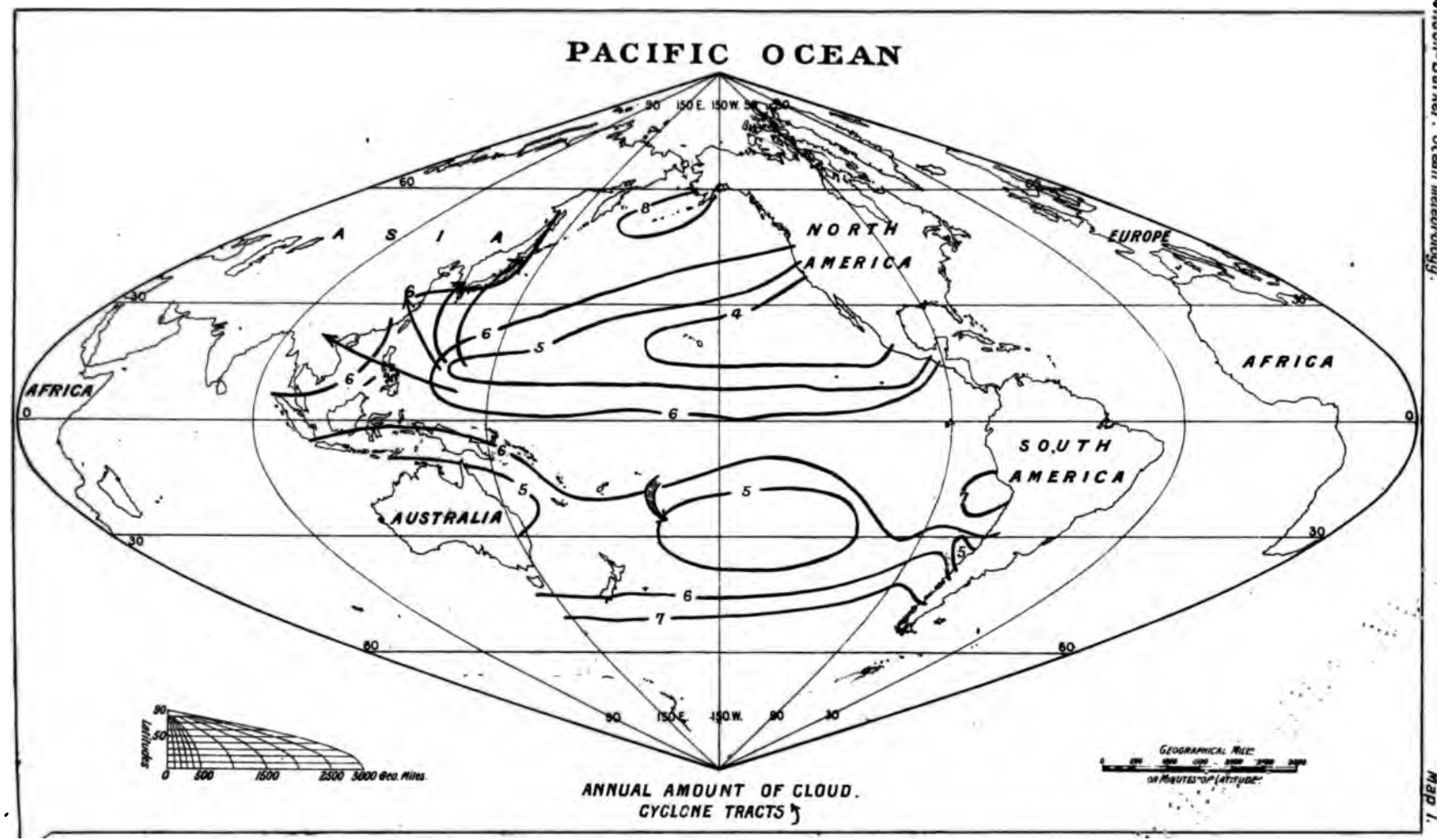
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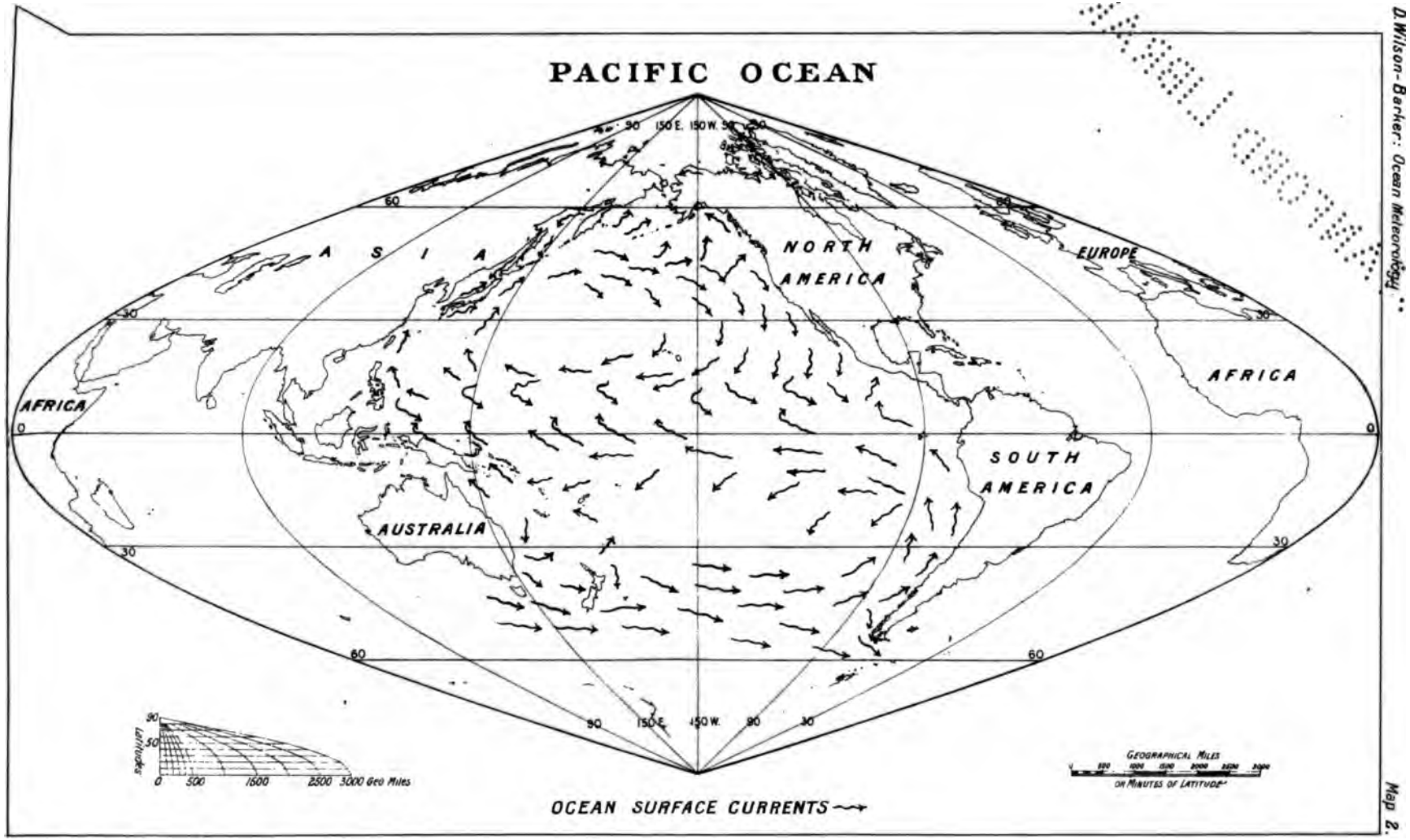
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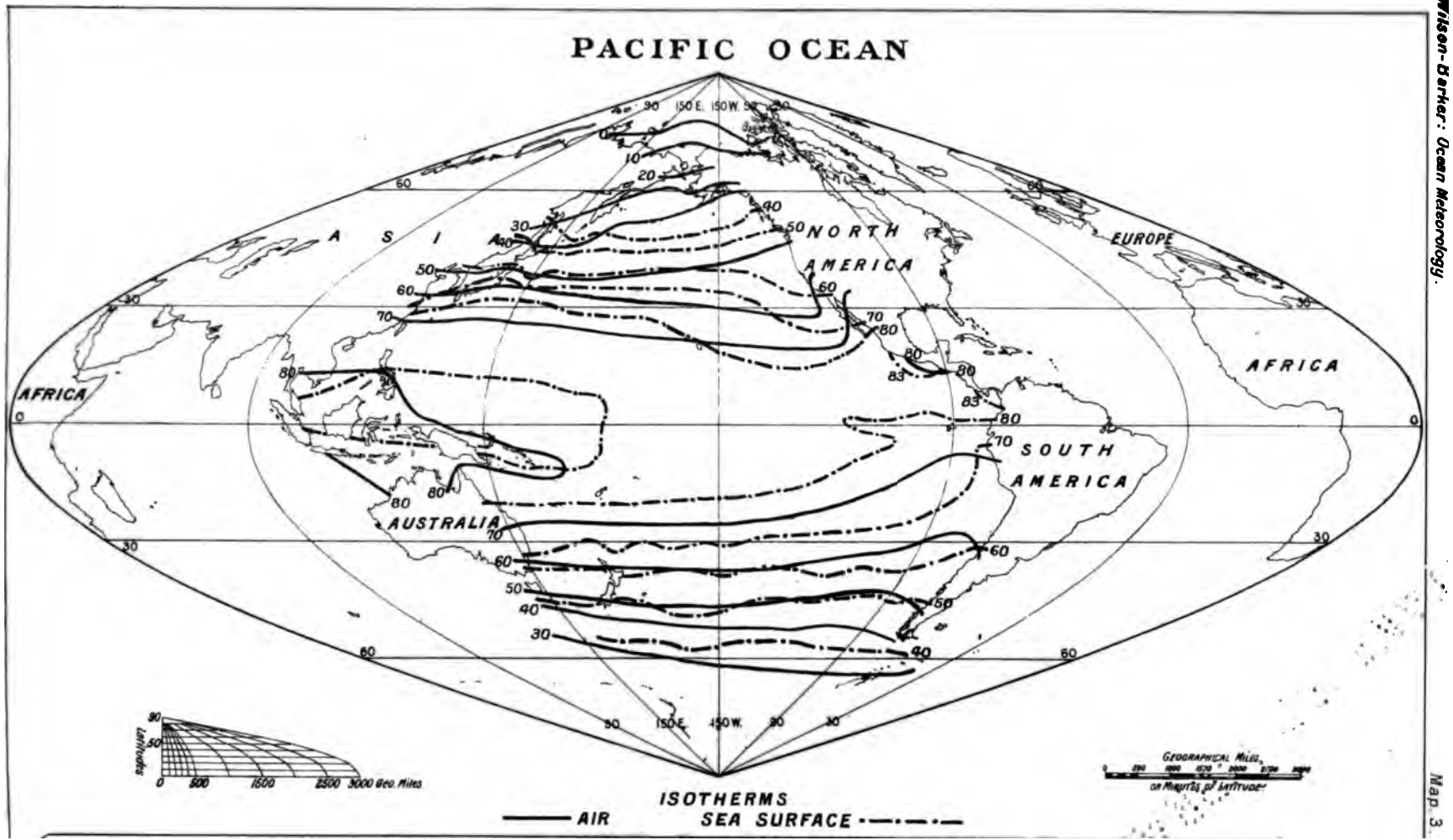
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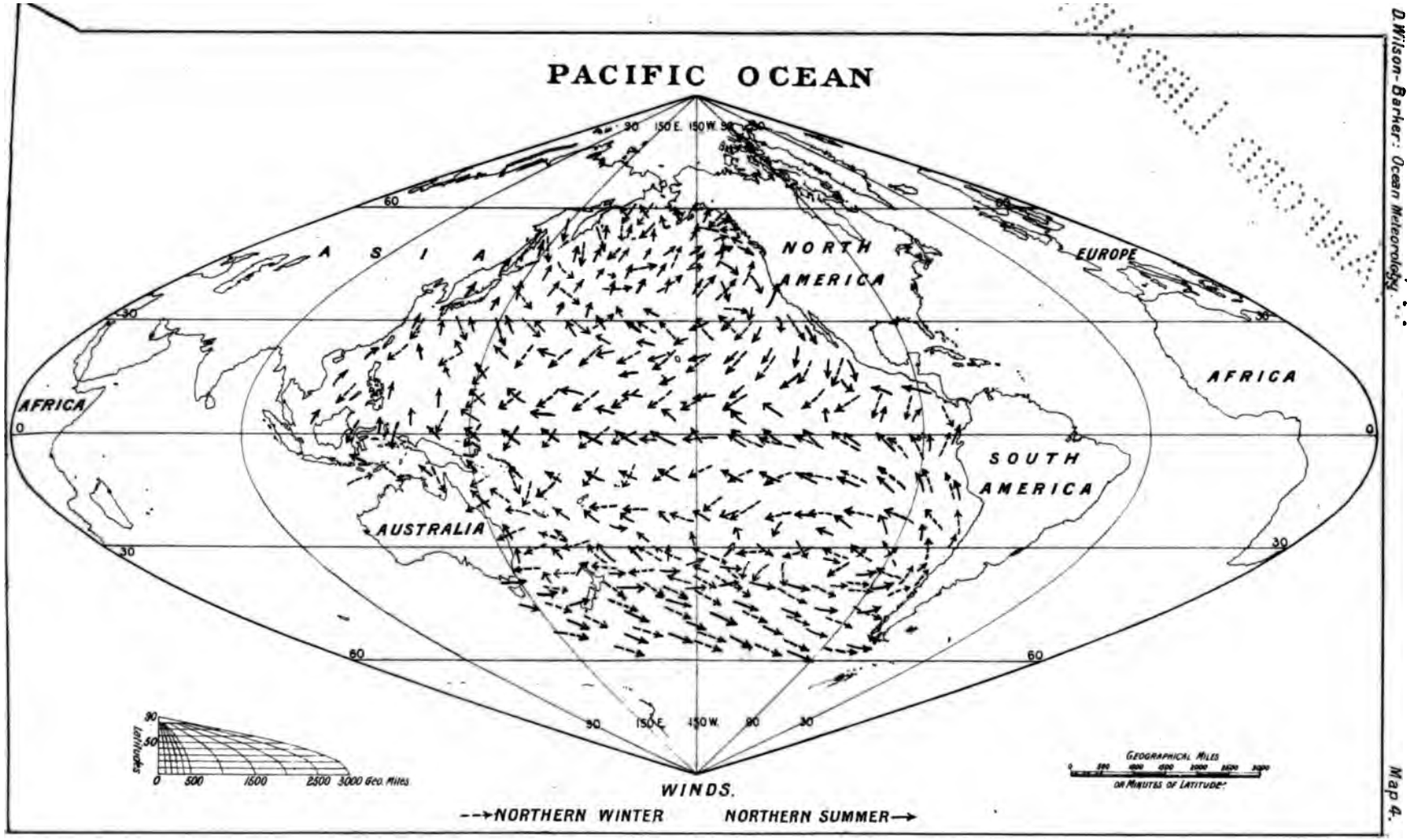
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PACIFIC OCEAN
ASIA
NORTH AMERICA
EUROPE
AFRICA
AFRICA
SOUTH AMERICA
AUSTRALIA
150 E.
150 W.
90
60
30
0
8
6
5
4
7
Latitudes
0
500
1500
2500
3000 Geo. Miles.
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE
ANNUAL AMOUNT OF CLOUD.
CYCLONE TRACTS

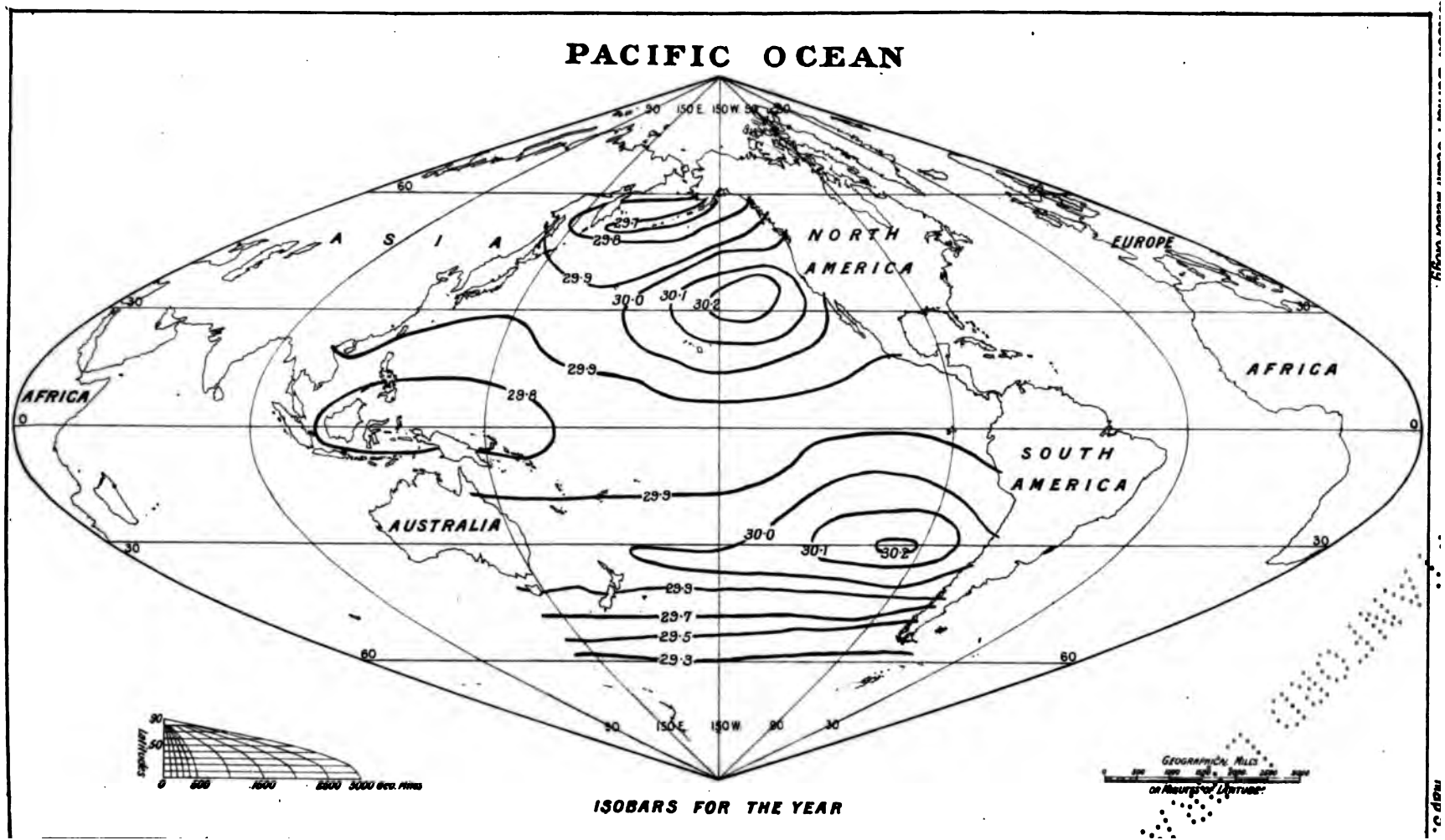

PACIFIC OCEAN
ASIA
NORTH AMERICA
EUROPE
AFRICA
AFRICA
SOUTH AMERICA
AUSTRALIA
90 150 E. 150 W. 90
60
30
0
30
60
90 150 E. 150 W. 90
LATITUDE
90
50
0 500 1500 2500 3000 Geo Miles
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE
OCEAN SURFACE CURRENTS

Map 2.

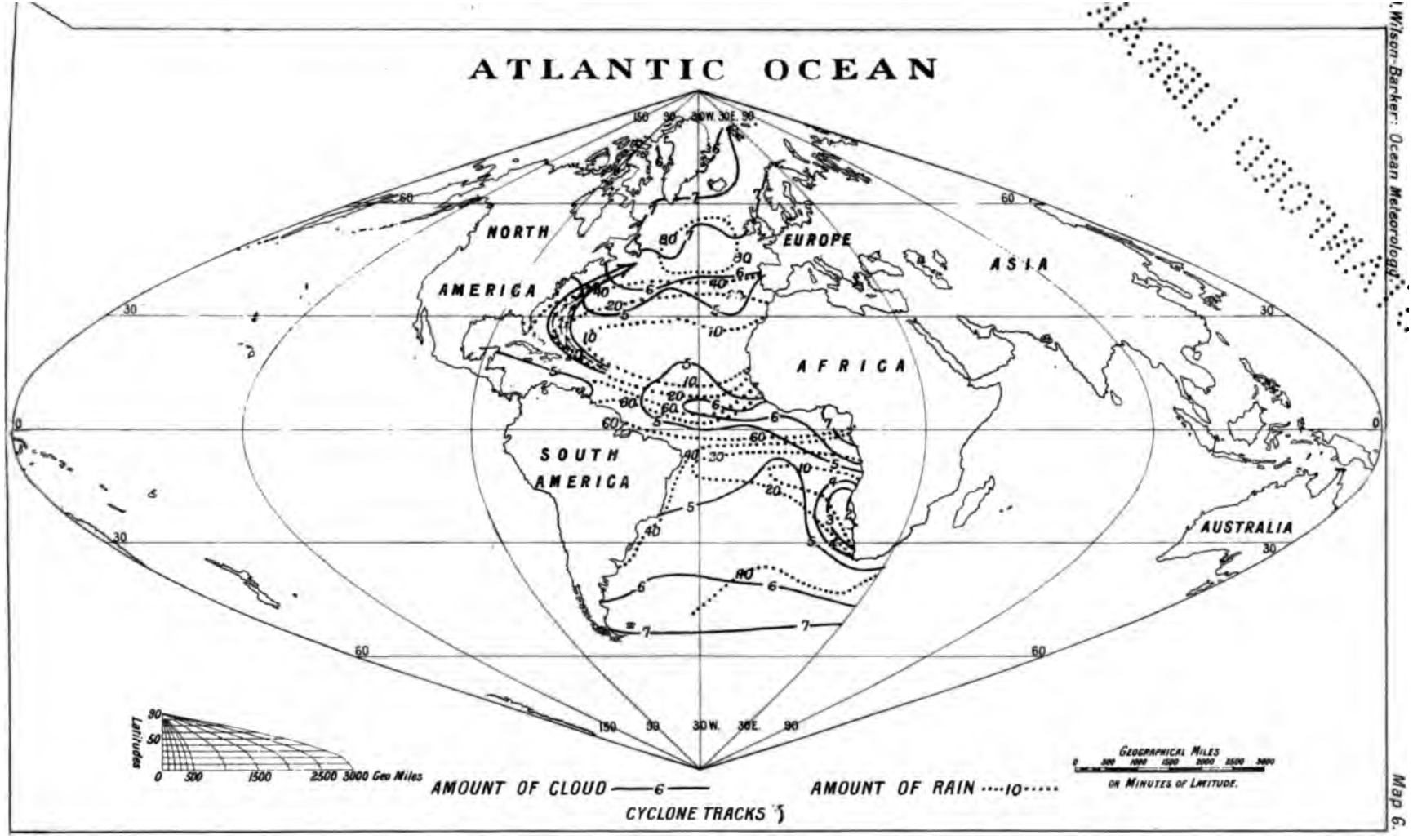

PACIFIC OCEAN
ASIA
NORTH AMERICA
EUROPE
AFRICA
AFRICA
SOUTH AMERICA
AUSTRALIA
150 E.
150 W.
Latitudes
0 500 1500 2500 3000 Geo. Miles
GEOGRAPHICAL MILES,
OR MINUTES OF LATITUDE.
ISOTHERMS
AIR
SEA SURFACE


PACIFIC OCEAN
ASIA
NORTH AMERICA
EUROPE
AFRICA
AFRICA
SOUTH AMERICA
AUSTRALIA
150 E.
150 W.
60
30
0
Latitudes
0 500 1500 2500 3000 Geo. Miles
Geographical Miles
or Minutes of Latitude.
WINDS.
--→NORTHERN WINTER
NORTHERN SUMMER→

Map 4.

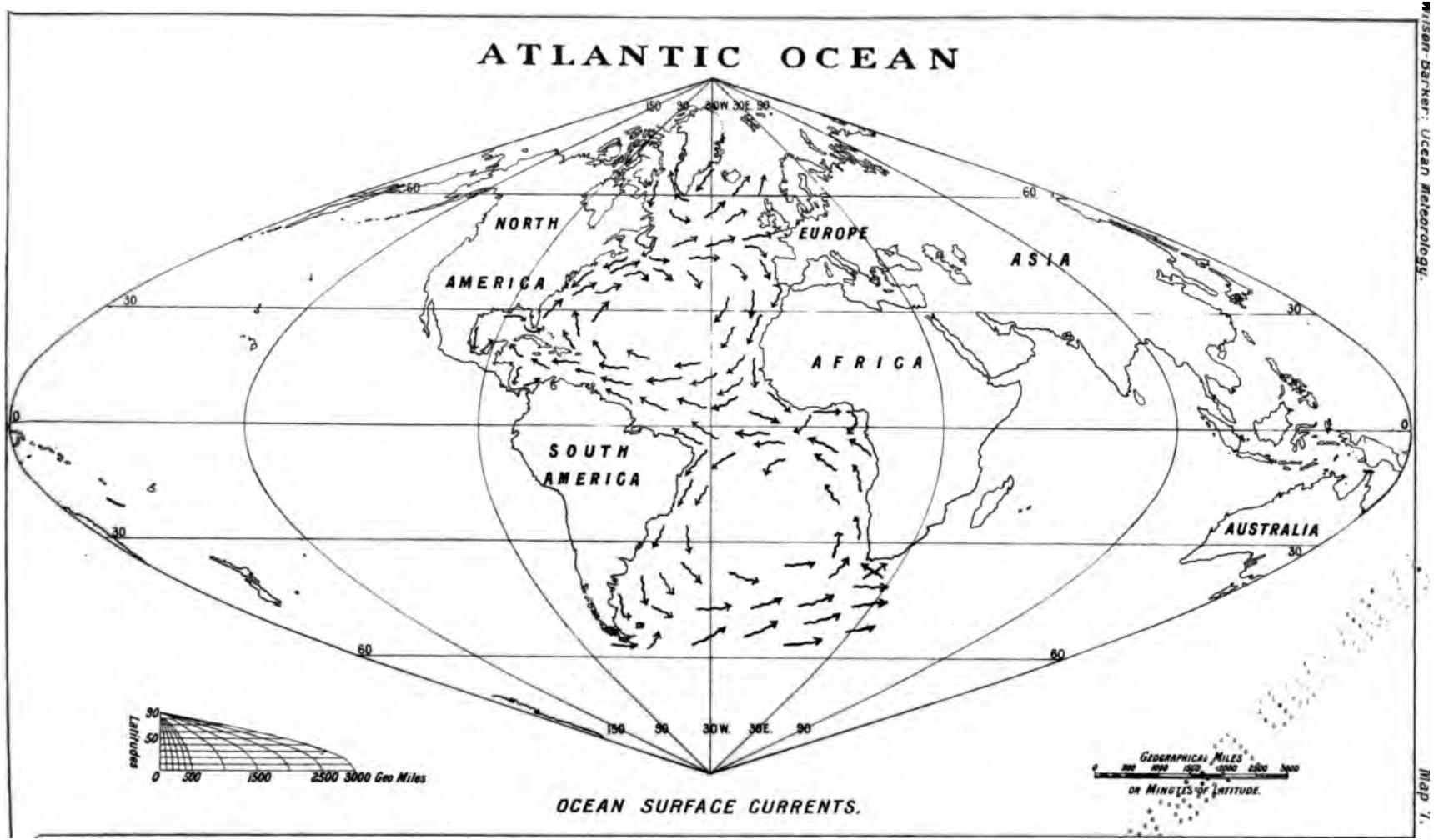


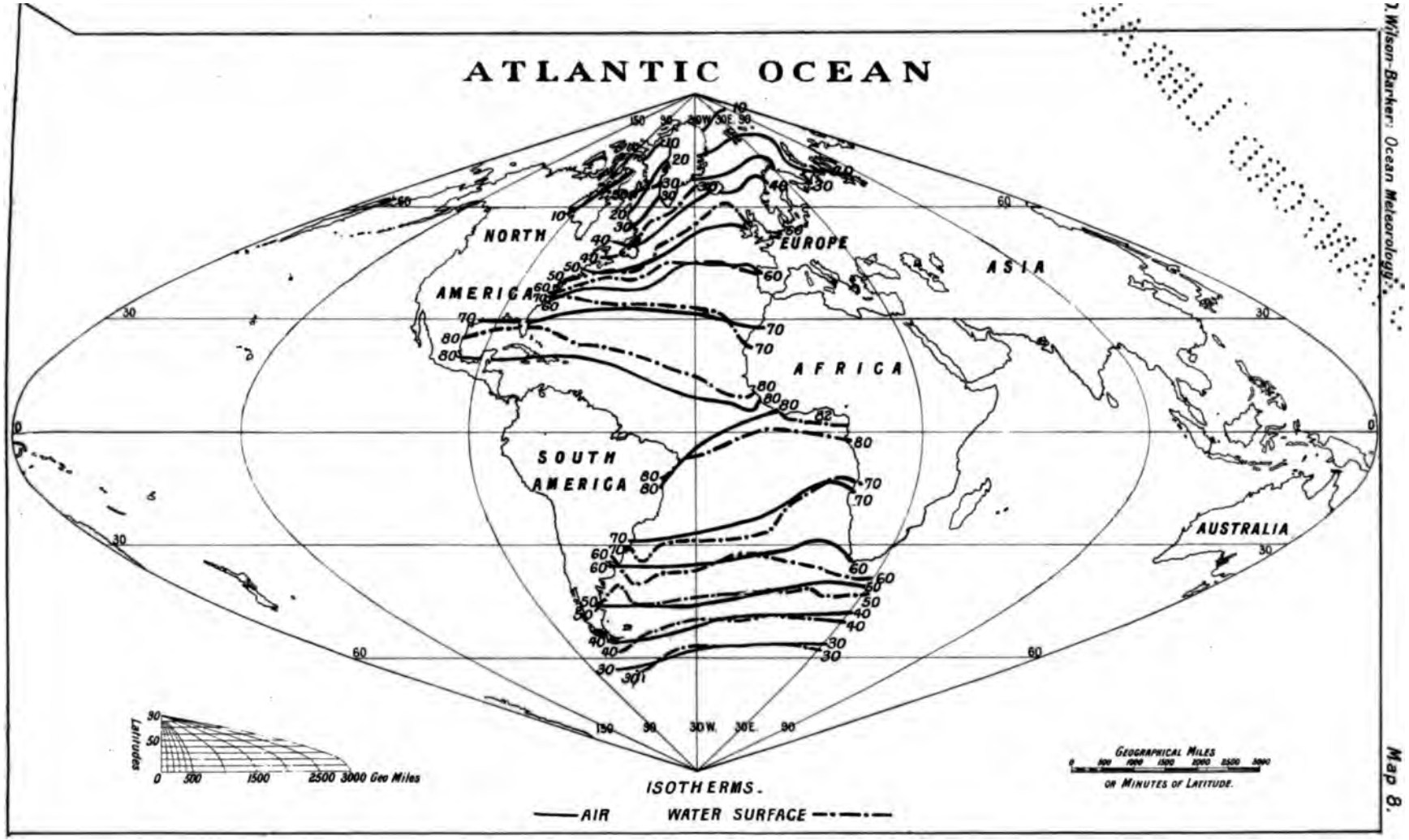
ISOBARS FOR THE YEAR



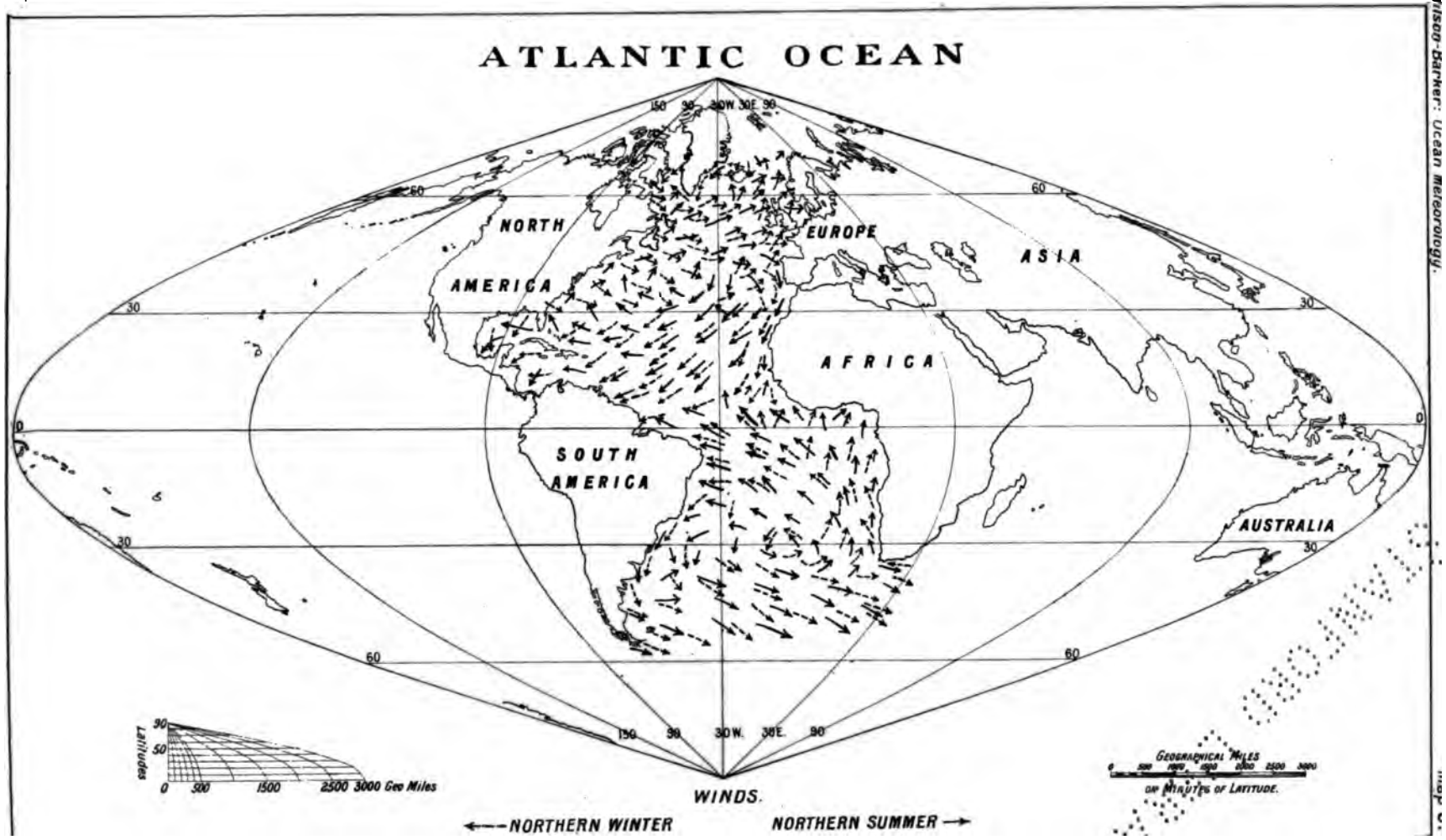
Wilson-Barker: Ocean Meteorology.

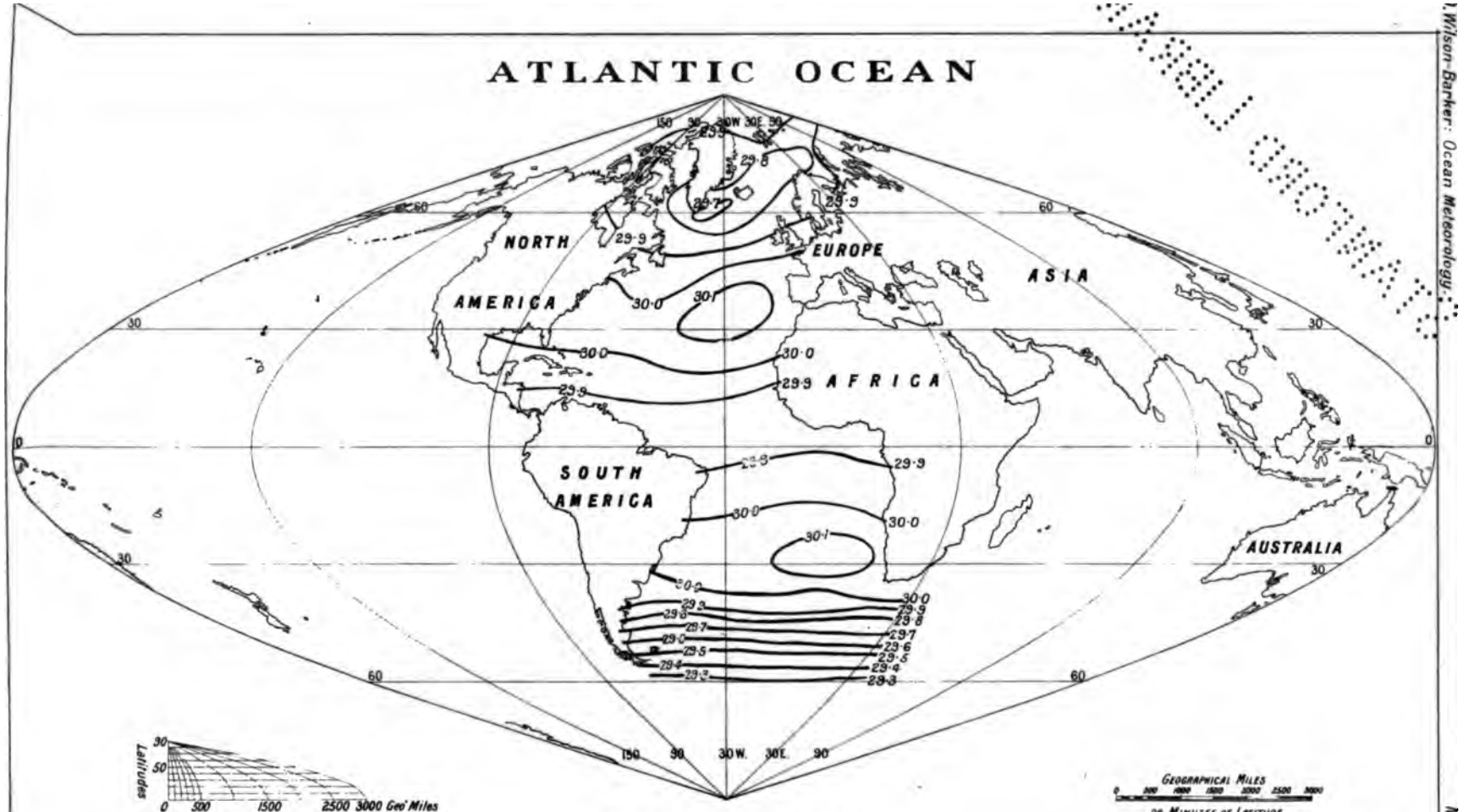
Map 6.


ATLANTIC OCEAN
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
150 90 30W 30E 90
60
30
0
30
60
150 90 30W. 30E. 90
Latitudes
90
50
0 500 1500 2500 3000 Geo Miles
Geographical Miles
or Minutes of Latitude.
OCEAN SURFACE CURRENTS.

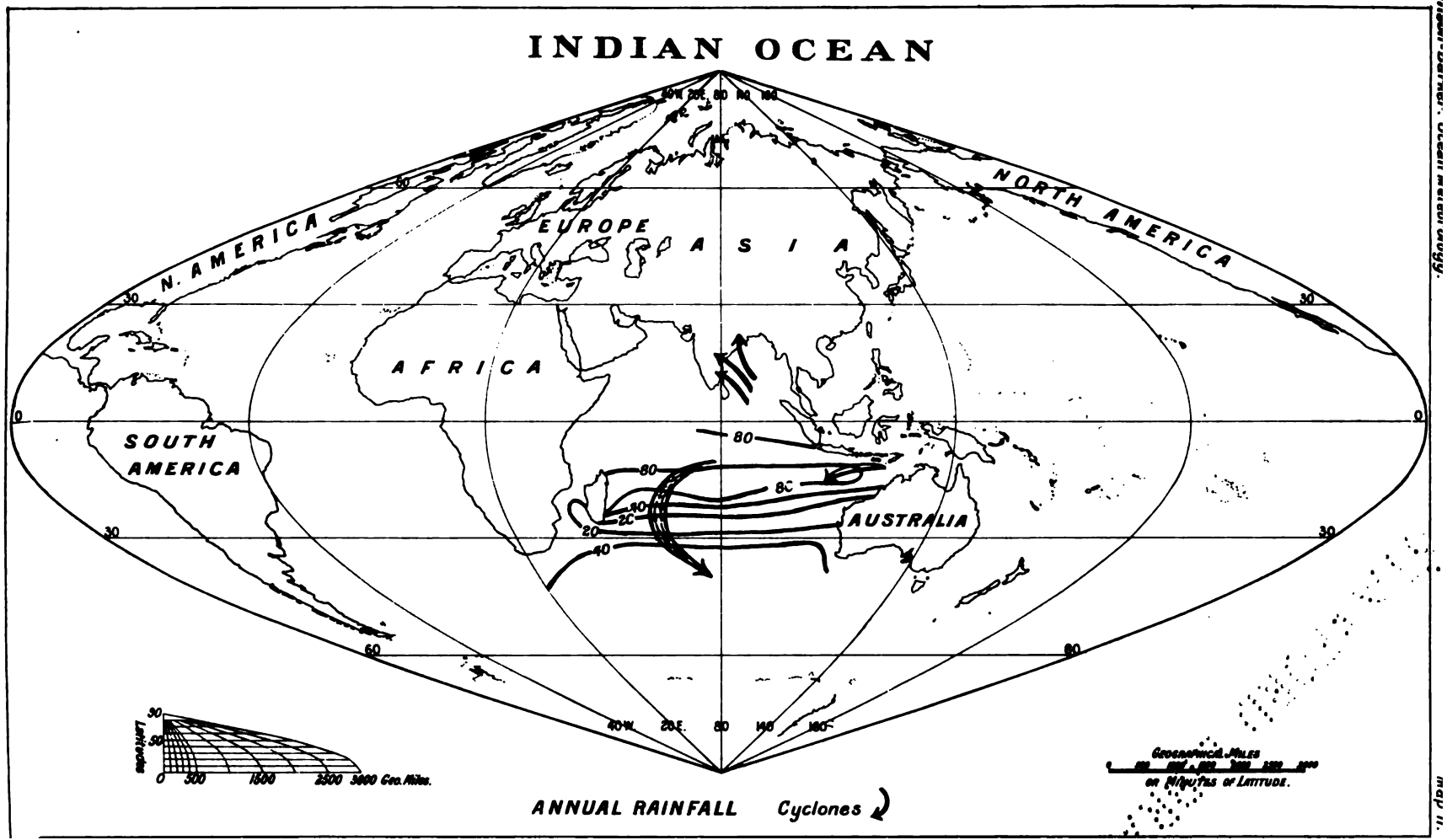

ATLANTIC OCEAN
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
Latitudes
0 500 1500 2500 3000 Geo Miles
Geographical Miles
or Minutes of Latitude.
ISOTHERMS.
AIR
WATER SURFACE

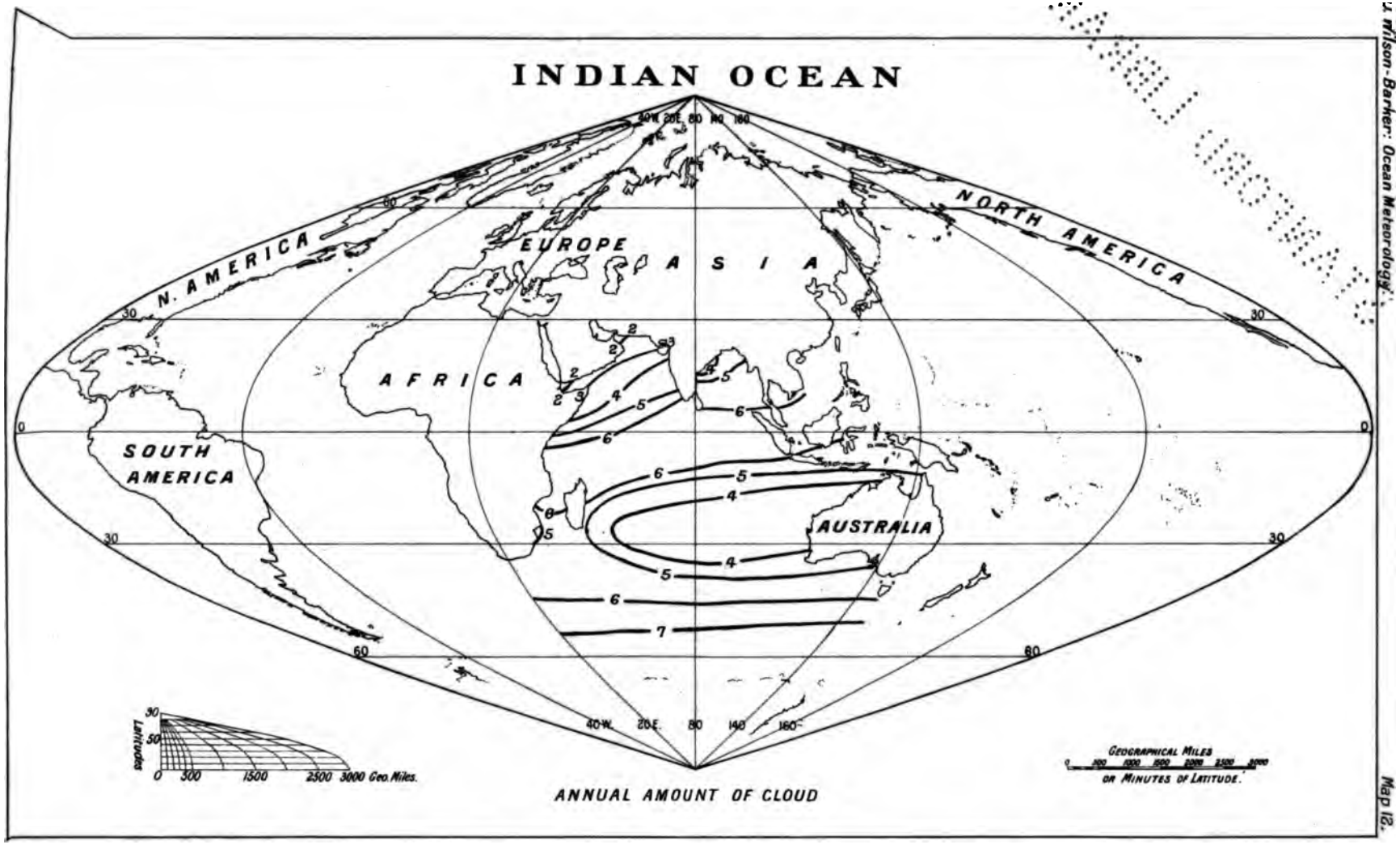
Map 8.


ATLANTIC OCEAN
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
150 90 30W 30E 90
60
30
0
30
60
150 90 30W. 30E. 90
Latitudes
30
50
0 500 1500 2500 3000 Geo Miles
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE.
WINDS.
←NORTHERN WINTER
NORTHERN SUMMER→



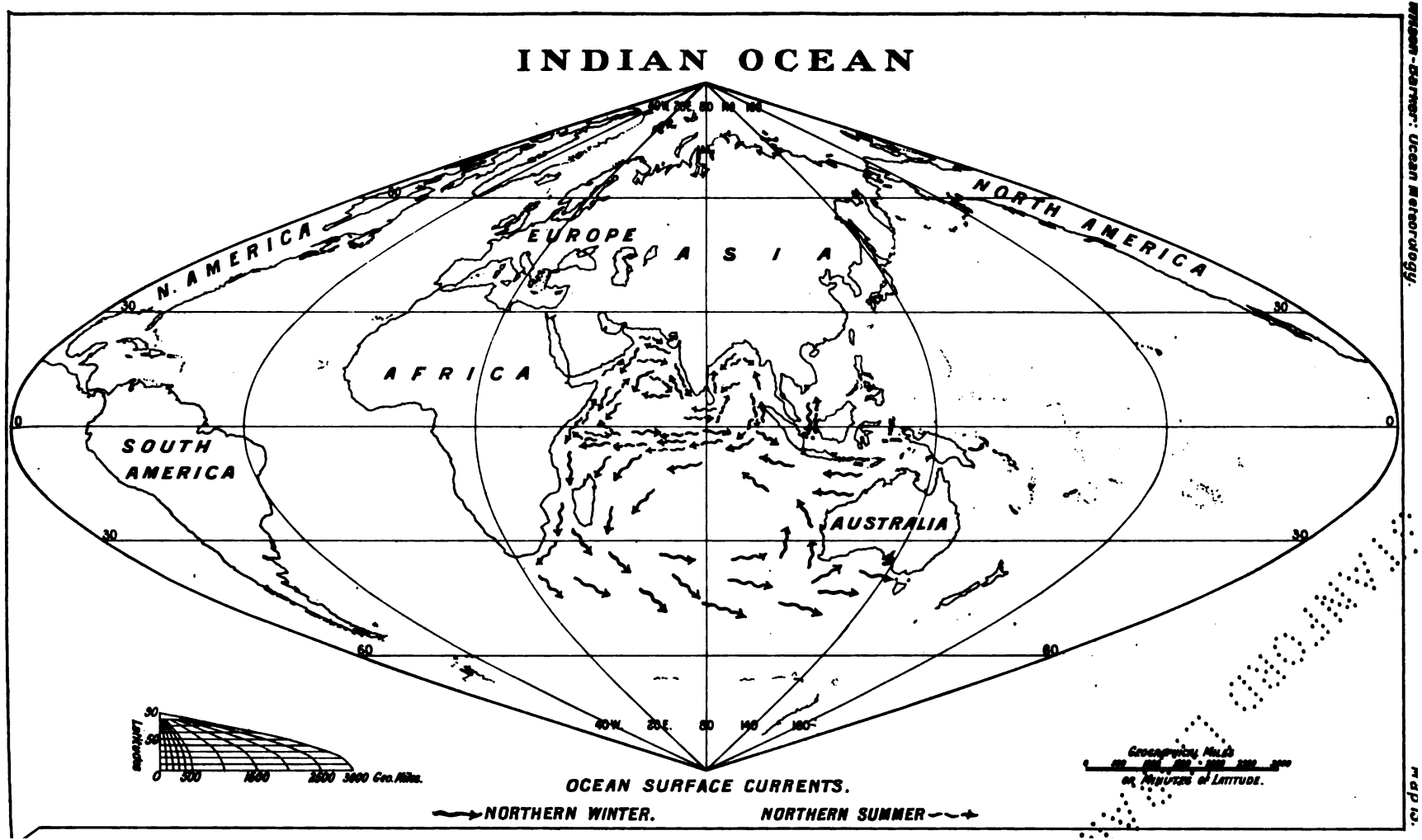
ISOBARS FOR THE YEAR.

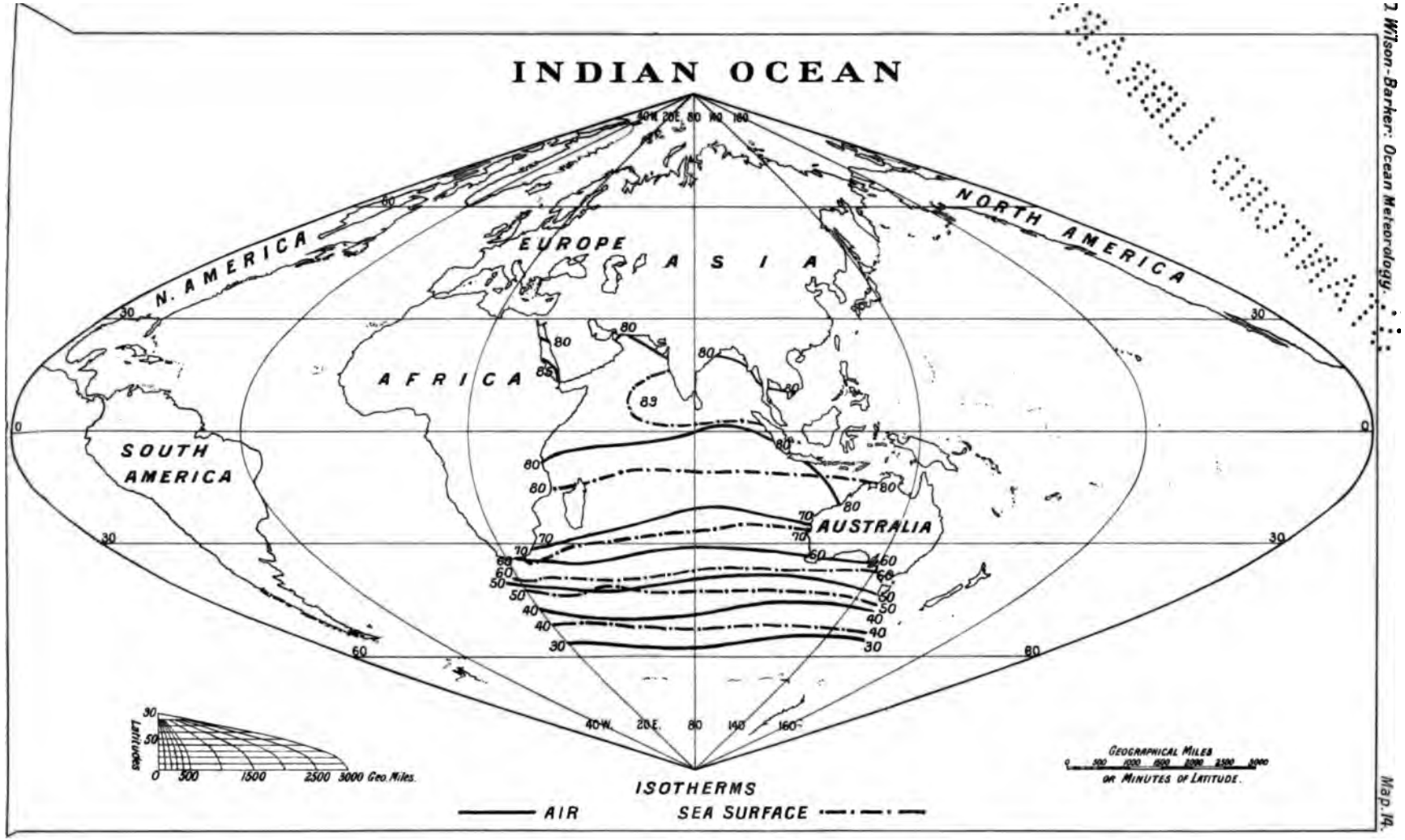

INDIAN OCEAN
N. AMERICA
EUROPE
A S I A
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
80
60
40
20
0
30
60
40W
20E.
80
140
180
0 300 1500 2500 3000 Geo. Miles.
ANNUAL RAINFALL
Cyclones
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE.

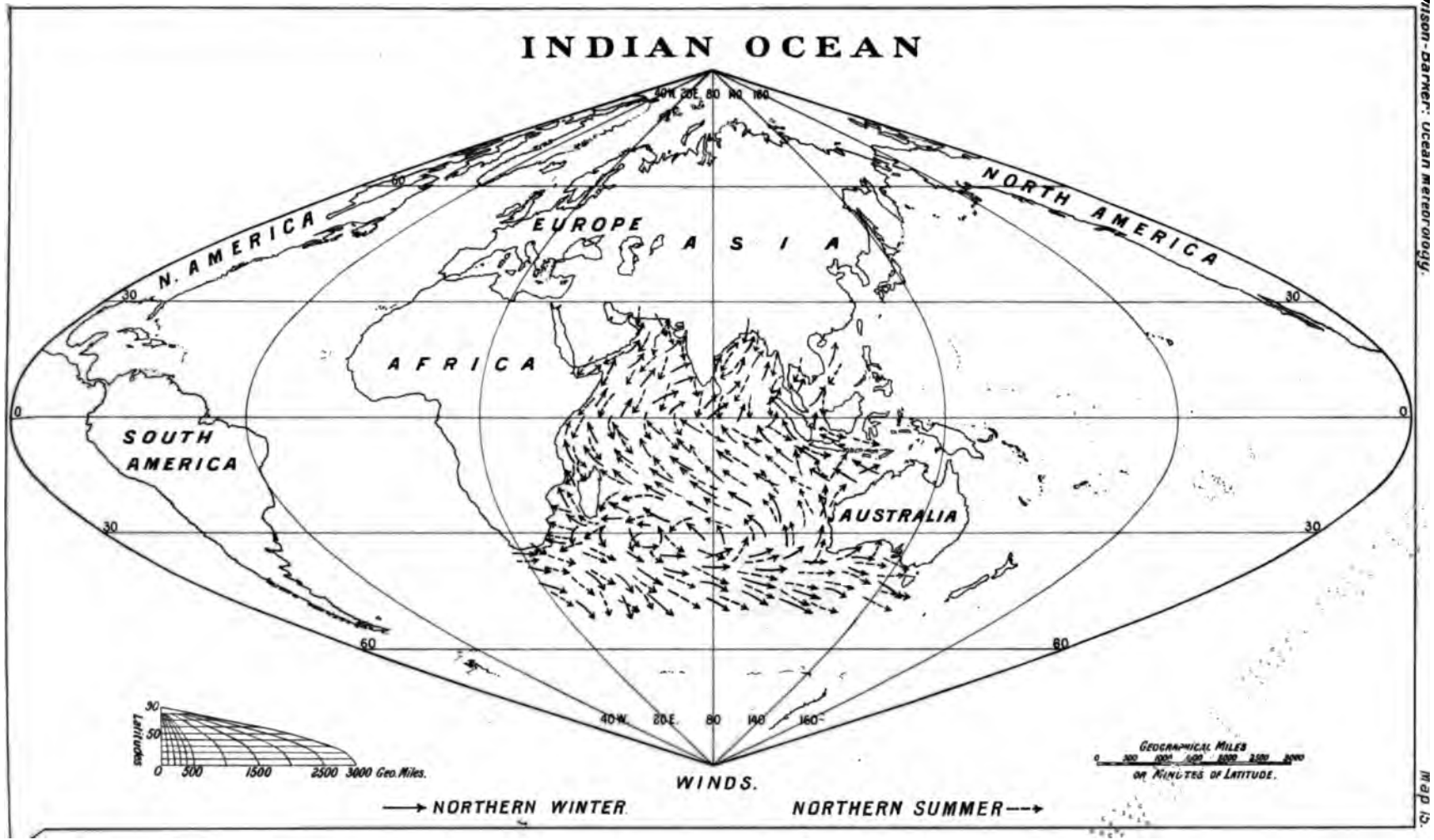


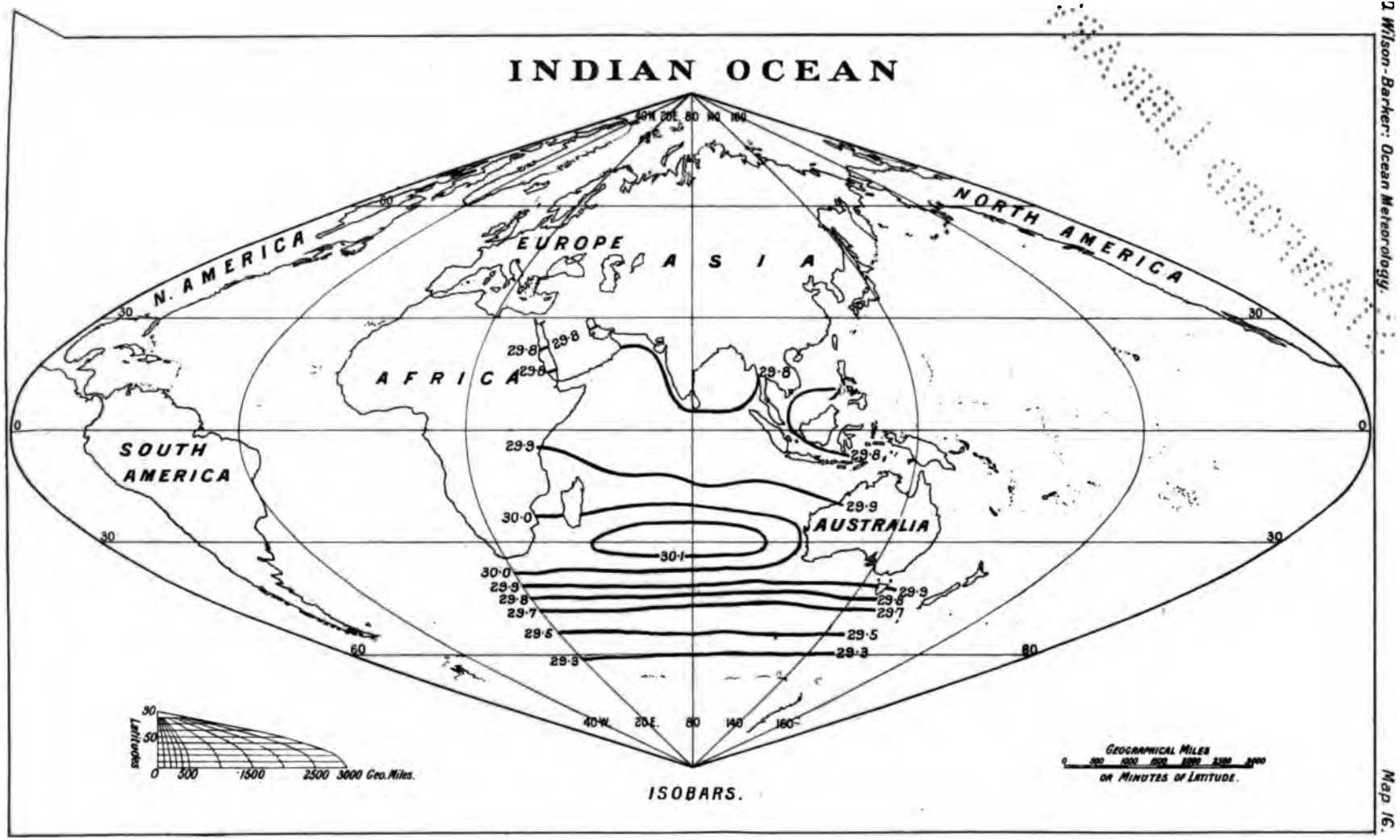
ANNUAL AMOUNT OF CLOUD

Map 12.


INDIAN OCEAN
N. AMERICA
EUROPE
A S I A
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
0
30
60
40W.
20E.
80
140
180
Latitude
50
30
0
500
1500
2500
3000 Geo. Miles.
Geographical Miles
or Minutes of Latitude.
OCEAN SURFACE CURRENTS.
NORTHERN WINTER.
NORTHERN SUMMER


INDIAN OCEAN
N. AMERICA
EUROPE
A S I A
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
ISOTHERMS
AIR
SEA SURFACE
LATITUDES
0 500 1500 2500 3000 Geo. Miles.
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE.


INDIAN OCEAN
N. AMERICA
EUROPE
A S I A
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
40 W. 20 E. 80 140 160
60
30
0
Latitudes
0 500 1500 2500 3000 Geo. Miles.
GEOGRAPHICAL MILES
OR MINUTES OF LATITUDE.
WINDS.
NORTHERN WINTER
NORTHERN SUMMER


INDIAN OCEAN
N. AMERICA
EUROPE
A S I A
NORTH AMERICA
AFRICA
SOUTH AMERICA
AUSTRALIA
40W 20E 80 140 160
0
30
60
29·8
29·9
30·0
30·1
29·7
29·5
29·3
Latitudes
0 500 1500 2500 3000 Geo. Miles.
Geographical Miles
or Minutes of Latitude.
ISOBARS.

QUARTERLY JOURNAL

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ROYAL METEOROLOGICAL SOCIETY

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THE PRESENT POSITION OF OCEAN METEOROLOGY.

BY COMMANDER D. WILSON-BARKER, R.N.R., F.R.S.E., F.R.G.S., President.

(Maps 1-16.)

[An Address to the Royal Meteorological Society, January 20, 1904.]

I.

I HAVE taken Ocean Meteorology as the subject of this Address, because I believe that the solution of many weather problems must be sought in close study of atmospheric conditions over oceanic areas. I think, too, that while anticipating the gradual increase of accurate information, and the filling up of the gaps in our knowledge of the subject, it is well to remember the enormous difficulties in the way of meteorological students. It is also wise to encourage ourselves by occasionally taking stock of the work done, and the results secured.

In recapitulating, we must recognise Captain Maury, of the United States Navy, as one of the earliest, as well as one of the most successful, of ocean meteorological pioneers. He collected the scattered shreds of available knowledge, and with enthusiastic, persevering energy, worked them into a comprehensive whole. He enlisted the services of a volunteer meteorological corps of sailors, which, under his guidance, did most excellent and useful work. Theories of winds and currents had certainly been promulgated long before Maury's day, but it was he who combined, assorted, and selected the materials which he afterwards utilised in giving to sailors the first comprehensive *Physical Geography of the Sea.*[1]

While Maury worked in America, another sailor, Vice-Admiral FitzRoy, was similarly occupied in England, where, as Chief of the Meteorological Department of the Board of Trade, he had ample scope for labours which were productive of valuable results. To these two sailors, but

[1] Maury's charming book passed through no less than twenty editions. It may still be read with interest and benefit.

especially to Maury, we owe the foundations of our knowledge of Marine Meteorology.

The recognised importance of this branch of science led to the International Conference on Meteorological Observations at Sea held at Brussels in 1853: this was followed, many years later (1874), by the London Conference on Maritime Meteorology, which was presided over by Prof. Buys-Ballot and was attended by able representatives of the principal nations. The Conference indicated the general lines to be followed in research work at sea, and these methods are still generally adhered to. Some countries have made a departure from the rules of the Conference, in altering the nomenclature of clouds; and it is certain that, in the future, considerable alterations must be made in the methods of estimating the force of the wind, those in use being very unsatisfactory.

I must here allude to the valuable work done in marine meteorology by Captain Henry Toynbee, whose wide experience as a sailor stood him in good stead at the Meteorological Office, where, for over twenty-five years, he acted as Marine Superintendent.

The progress of maritime meteorology was summarised by Mr. Scott, in a paper read before this Society, May 17, 1876, and again in his Presidential Address in 1886. On each occasion Mr. Scott ably surveyed our knowledge of the subject, and suggested methods of further development.

The primary object in view in early marine meteorological observations was the welfare of the sailing vessel; the determining of the best and safest routes; and the aid to forecasting the weather found in theories deduced from observations taken. In the seventies the sailing ship reached the zenith of its perfection and its usefulness.

Although great advance had been made in the science by the year 1886, there still remained many ocean areas from which no observations whatever had been taken: this was notably the case in the wide regions of the Pacific Ocean. Many useful charts and maps of the ocean areas, which had been more or less explored, were made at this period. In England the Meteorological Office issued the *Charts of Meteorological Data for nine* 10° *squares of the Atlantic which lie between* 20° *N. and* 10° *S., and extend from* 10° *to* 40° *W.* (1878), and the *Meteorological Charts for the Ocean District adjacent to the Cape of Good Hope* (1882). The Admiralty brought out their *Wind and Current Charts* (1872). The Hydrographic Office of the United States issued an important work in the *Pilot Charts of the North Atlantic Ocean.* Germany produced the *Atlas* of thirty-six charts of the Atlantic Ocean, and France contributed Brault's *Cartes des Vents.* All these publications were of the utmost importance to navigators, as well as to meteorologists. In this same decade, 1876 to 1886, took place the great expedition of the *Challenger*, and also the Norwegian Atlantic Expedition of the *Voringen;* but the results were not printed or made public until some years later.

II.

We are too apt to deal with meteorological conditions from purely local aspects, whereas no subject requires a more wide-world outlook, or more constant reference from particulars to the whole, of which the vast

areas of the ocean world form so great a part. The greater demand and the superior facilities for land observations, as well as the difficulties in the way of taking observations at sea, account, in great measure, for the comparative backwardness of meteorological science. Useful as land work, in this connection, may be, it cannot fail to be often misleading, owing to the complications, or eddies, set up in the weather systems by irregularities in the surfaces of the land. We live at the bottom of the atmosphere, and, until quite recently, have had but scanty means of penetrating higher regions, and thus have been unable to obtain much accurate data of meteorological phenomena. We may reasonably hope that the exploration of the upper air will become comparatively easy with the perfecting of the various methods now used for that purpose.

The primary cause of meteorological phenomena is undoubtedly the difference of temperature existing at the poles and the equator. Were the earth entirely covered by deep sea, weather effects would probably follow a regular sequence, and the task of forecasting would be easy. The difference of temperature at the poles and equator, together with the motion of the earth, produces a gigantic system of atmospheric whirls, in which the general tendency of the land influences is to produce local eddies, such as are often found in the main stream of a river. These eddies in some localities, particularly in India, violently disturb the main whirl streams.

The majority of the maps[1] which I propose to show to-night are drawn on what is called Flamsteed's projection, in which, while considerable distortion appears at the edges, the areas are all equal, an important point, I think, in demonstrating meteorological conditions. By presenting the oceans on three separate maps, the distortion has been reduced to a minimum. We are so accustomed to the use of Mercator's map, that we fail to notice the very exaggerated distortion appearing thereon. (Maps 1-16.)

Pressure and Wind.

The most striking features of barometric pressure are what may be termed the permanent areas of high pressure, prevailing in the Atlantic and Pacific Oceans, in the latitudes of 31° N. and S., and on the eastern sides of these oceans. That these areas should correspond with the 31st parallel of latitude is interesting, as that is approximately the line which divides the hemisphere into two equal parts.[2] The coincidence is significant. These high-pressure areas exert a great influence on all weather phenomena, and they are worth close study, as they possibly afford a key to the solution of many problems. I do not think their importance is fully realised. Their influence on the conditions of the sea must be great: they are at once barriers and feeders to the air flow, and they have much influence on the irregular path of cyclonic disturbances. Thanks to the labours of Dr. Buchan, F.R.S., we have excellent charts of these areas: in working out the results of the *Challenger* Expedition, he had an immense mass of accurate data at hand, and he made good use of

[1] In the preparation of these maps I have consulted the authorities mentioned in the Appendix, particularly *Bartholomew's Physical Atlas*, vol. 3, the charts issued by the Meteorological Office and the Deutsche Seewarte, and my own observations in high Southern latitudes, Eastern Pacific, Atlantic, and Indian Oceans.

[2] The exact parallel is 30°.

it. It was he who first drew isobaric charts for the globe, and he edited the splendid *Atlas of Meteorology*, recently published by Constable and Co., a most valuable contribution to the science.

In the South Indian Ocean we still find the area of high pressure at about the 31st parallel, but much extended, stretching indeed almost across the ocean. To the north-west, in the North Pacific, and to the north-north-west, in the North Atlantic, we find a low-pressure area, almost as permanent as the high-pressure area, but subject to greater fluctuations in level. In the southern parts of these oceans, and in the Indian Ocean, there seems to be a general low area round the South Pole, though here also areas of high pressure may possibly be included. This is one of the Southern Ocean problems which it is hoped the present Antarctic Expedition will help to elucidate. The continually stormy South-easterly winds and the backing of the wind from South-east to West, as experienced by the *Discovery*, would seem to point to the existence of a higher barometric pressure in these regions.

The force of the South-west Monsoons is due, probably, to the extended area of high pressure in the Indian Ocean, the air supply from this area being much more ample than that which feeds the North-east Monsoon from the great Asiatic table-land.

We find a state of low pressure round the globe, in the equatorial regions, where, nevertheless, there must be a considerable depth of atmosphere, owing to the expansion existing there, causing the upper part to overflow polewards.

As pressure and wind naturally go together, we find a marked connection between the trend of the wind and the permanent areas of high and low pressure. Broadly speaking, there is a Westerly wind round both poles, in latitudes 40° to 60°. North and south of these belts such winds as have been studied appear to be Easterly. This tends to confirm the opinion, already expressed, that patches of high and low pressure are probably to be found at each pole.

The polar East winds, generally known as the Trade winds, are separated from these Westerly winds by belts of variable winds and calms, in which the high-pressure areas are situated. The South-Easterly Trade winds extend to the equator, northward of which occurs another belt of varying winds and calms, the meeting places of the "Trades."

Examination proves that these general wind systems are governed by the permanent high-pressure areas, which act as feeders to the wind systems, and also to the succession of cyclonic disturbances passing along on the polar sides of the Trade-wind regions. In the North Indian Ocean, in the Gulf of Guinea, and in the East Indian Archipelago, we find marked alterations in the direction of the winds, caused by the changes of season. The resultant phenomena are known as "Monsoons," a term now used in a more comprehensive sense than formerly. No other natural phenomenon has been so much observed as the direction of the wind, because of its influence on navigation. Our information is voluminous, and yet we seem as far as ever from any real knowledge of the laws governing the wind's movements; their action seems so involved that, so far, it has been impossible to disentangle and distinguish the separate springs of movement.

There is probably a more complicated vertical interchange of air

currents than would appear to be indicated by the various schemes. Recent investigations made in this branch of meteorology in America, under the guidance of Prof. Willis L. Moore, tend to prove that continual changes occur in the front and rear of cyclonic disturbances. These changes are indicated by cloud forms, particularly by cirro-cumulus, which plainly show cross and interlacing currents.

So far as concerns the Trade-wind regions, it is certain that there is an upper current from a Westerly direction: this is particularly noticeable in the North-east Trades, where upper clouds are more prevalent than in the South-east Trades. An Easterly movement of the upper atmosphere has been reported from the equatorial regions, but it is yet to be proved that this is more than a merely local occurrence. The trials on the upper atmosphere, now being made by means of kites and balloons, promise to throw much light on these complicated questions.

It will be found, I think, that while local conditions vary considerably, the winds are fairly regular in their great general circulation. Local causes govern the Monsoons; in India, for instance, they result from the alternate heating and cooling of the great Asiatic continent: this same far-reaching influence operates on the "Trades" in the Indian Ocean, where the South-west Monsoon—which is an extension of the South-east Trades—often becomes a gale accompanied by bad weather over a great part of the north Indian Ocean. The effect of the Asiatic continent on the North-east "Trades" is rather to lessen their force.

It is desirable that more attention should be paid to the force of the wind at sea. Allowance can be made for the speed and direction of the ship. The direction of the wind should be deduced from the curl on the waves. The scale of force should be revised, and a better basis of operations could hardly be selected than the conditions of the sea surface.[1]

Storms.

We know that storms are largely fed by anticyclones, but of their origin, mode of propagation, and growth we know little. Indeed, in knowledge of the causes of storms and the movements of the air we are but little ahead of Piddington and Reid. Quite recently, however, Dr. W. N. Shaw, F.R.S., has advanced some novel theories, which, if correct, will tend to change our views of wind circulation, and will explain much that hitherto appeared inexplicable in its mode of progression. American meteorologists are also keenly investigating the question of wind in storms.

On the polar sides of the Trades we meet a constant succession of storms moving in an Easterly direction. These districts are commonly called the "Roaring Forties," from the parallels in which they move. The undeveloped state of the quadrant from polar West to polar East in most cases in these storms is their most peculiar feature, and is owing, probably, to the fact that these storms are fed from the equatorial side. In high southern latitudes the fall of the barometer is much more rapid in front of the storm than is the corresponding rise in its rear. Successive gales such as these storms are unknown in the Tropics and in

[1] "Comparison of Estimated Wind-Force with that given by Instruments," *Quarterly Journal Royal Met. Soc.*, vol. **25**, p. 13.

the Trades, though the latter often attain gale force, and cyclones (which are storms of intensified force) prevail in certain parts. Cyclones are generally met with on the westerly sides of the oceans, they vary much in their path, and their point of origin is unknown. Other cyclonic regions are the Indian seas, the China Seas, Mauritius, and the South Pacific.

Temperature.

The uniformity which prevails in meteorological conditions over ocean surfaces, as compared with the variations encountered over land areas, is evidenced by the very slight differences in the temperature of the sea surface and in the air above it. The influence of the sea on the lands adjacent to it is varied and remarkable: thus, in latitude 40° off New York, on the North American coast, we get a mean annual temperature of 52°, while in the same latitude, off the coast of Portugal, the mean temperature is 63°. Such instances might be multiplied. The wonderful amelioration of the climates on the north-east side of the oceans is almost entirely due to the ocean drift, which carries warmth with it into higher latitudes on the east side. England and Germany have worked at the collection of sea and land temperature data. The work of cable-laying affords excellent opportunities for testing the temperature of ocean depths, but the methods in use are antiquated and tedious. It is strange that no practical electrical contrivance for taking deep-sea temperatures is yet forthcoming.

Ocean Currents.

The direction of the wind was formerly the chief meteorological concern of the sailor: his principal interest nowadays is probably in ocean currents. Maury and other sailors used the term "ocean drift," thereby recognising the influence of the wind in the regulation of these movements. Opinion is still much divided as to the cause of these currents. My own belief is that the primary origin of all meteorological phenomena is the difference of temperature existing at the poles and the equator, and that once a slight initial movement is started, action and reaction set in, culminating in the general conditions universally experienced. I am aware of geological difficulties to this view, but they may, I think, be explained by unequal distributions of land or change in the position of the poles. The influence which the great barometric pressure exerts on the water level is apt to be somewhat overlooked. The actual difference of level between, say, the centres of the high and low pressure areas is very considerable. It is possible that the depression of the ocean under the areas of high pressure may set up slight currents from the outside water: the motion of the earth on its axis would, of course, modify the direction of such currents. Pettersson and Meinardus have shown that there may be connection in winter between the barometric pressure over ocean areas and the temperature of their surface waters.

In their grand circulation ocean currents follow almost exactly the same course as the winds; but as in the various wind systems there are local eddies, called storms, so there are disturbances in the water currents, which, in conjunction with the variations of speed in the main

drift current, cause infinite trouble to navigation. The Meteorological Office has recently devoted much attention to the matter of Current Directions, and sailors would do well to inform themselves of the results obtained. To deal properly with currents, navigators require accurate knowledge: it may be as disastrous to allow too much margin for their action as too little.

Dr. H. N. Dickson, F.R.S.E., has made a careful study of North Atlantic streams, and has ascertained that they vary in strength from year to year. In both the Pacific and Atlantic the currents follow tracts corresponding to those followed by the winds, but in the Pacific the strength of the northerly drift is much less than that of the northerly drift in the Atlantic, probably because the former is impeded and broken up by the islands to the north-east and north of Australia, and consequently a quantity of water is diverged into the Indian Ocean. Again, the presence of monsoonal winds in this area does not permit the "blowing home" of the Trades, as is the case in the Atlantic.

Coral reefs and their growths are intimately connected with ocean currents, and their study ought to afford valuable clues to the flows of those currents. In these days of steam, and of varying speeds, it is difficult to calculate the flow of a current. The surest, and certainly the simplest, method is by bottles thrown into the sea at different points. Mr. H. C. Russell, F.R.S., the Government Astronomer of Sydney, in the Southern Oceans, and the Prince of Monaco, elsewhere, have been very successful with bottle experiments. The American Hydrographic Office has also published results obtained in a similar way.

With regard to submarine currents we are confronted by the difficulty of exploration. We live on the dividing line, between the hydrosphere and the atmosphere, and at present we can, to a great extent, only infer what takes place above and below us. But until we know definitely the directions in which the great bodies of water move, we can never hope to attain any accurate knowledge of the laws of ocean circulation. Private enterprise[1] is helping much round our own coasts, but what is necessary are extended, world-wide operations, and these can only be undertaken with the help of the different Governments.

Rainfall, Snow, Hail.

The question of the rainfall is, perhaps, the most unsatisfactory with which to deal in ocean meteorology. Our information on the point is extremely limited. Rainfall observations at sea are constantly advocated in this country and abroad; but there are many difficulties, of which the greatest is the deflection of the rain by the sides of the ship. With the help of the gauges now procurable for the purpose it ought to be possible to get together the necessary reliable data. We are indebted to Dr. W. G. Black, a Fellow of this Society, for the information we already possess on the matter, and it is anticipated that his continued investigations will be productive of good results. Observations have been taken, hitherto, almost exclusively in the Atlantic and South Indian Oceans. I think the rainfall in southern latitudes is under-estimated; the weather in these

[1] As instanced by the excellent work done in the Faroe-Shetland Channel by Dr. R. N. Wolfenden, and described by Dr. H. N. Dickson, in the *Geog Journ.*, vol. 21, p. 418.

regions is constantly stormy or bad, except for an occasional brilliantly fine day. It would be possible to get rough calculations of ocean rainfall from sailors' logs, but these are unlikely to take count of the severity of the downpour, particularly in squally weather. Rainfall at sea is the result of evaporation from the ocean surface. With the exception of the work done by Schott there exist no returns of such evaporation. An approximate calculation, based on land returns, would be altogether misleading, as land and water have very different effects on the process of evaporation. The density of the sea is greatest in the Trade-wind regions, and evaporation is there most copious. As the polar regions are approached snow replaces rain. Hail occurs at sea under much the same conditions as on land: it generally accompanies squalls following in the rear of storms, sometimes it accompanies thunderstorms. The most important factor in all weather changes is moisture, which is always present in the atmosphere, though in small quantities. It is likely that, in the future, the spectroscope may be found useful in gauging the moisture of the atmosphere: the psychrometer, which is in constant use at sea for this purpose, is not a satisfactory method of record.

Cloudiness.

Descriptive observations of clouds at sea are not numerous enough. Ocean areas are more constantly cloudy than land, because of the greater amount of moisture in the atmosphere. The least cloudy ocean area is the Trade-winds region, and the South-east Trades are less cloudy than the North-east Trades. There is an almost total absence of Cirrus cloud in the South-east Trades of the Atlantic Ocean. Different types of cloud characterise certain areas of the ocean. Thus Stratus and Cirrus are the most common in the North-east Trades, Cumulus in the South-east Trades. Cumulus of various forms distinguishes the calm belt of the tropics and the polar sides of the Trades, particularly in the Northern hemisphere. The greatest cloud region in the world is probably that of the calm tropical belt. I have never elsewhere seen such mighty masses of Cumulus or such wonderful tangles of high Stratus and Cirrus. The important part played by moisture in the atmosphere is seen in the changes occasioned by the presence of even a small quantity: we must, too, remember the enormous expansion undergone by the moisture before becoming vapour. I think that atmospheric changes effected by the presence of terrestrial dust are not so important as supposed. The rapid appearance and disappearance of clouds, the transparency of the atmosphere, and the blue of the clear sky are matters of interest and importance, illustrating as they do variations of atmospheric absorption.

Fogs.

The unstable equilibrium between water and air existing at the sea surface is a primary cause of sea fogs, mirage, and their allied phenomena. They are a result of difference of temperature and a more or less calm state of the atmosphere. As long as the calm endures, the diverse temperatures do not intermix, but they occasion some remarkable phenomena, both of light and sound, which are often a grave danger and

anxiety to sailors. The navigation of a ship is an immeasurably more difficult task in a fog than in the wildest storm encountered. The vagaries of sound in fog are well known, but they are often almost inexplicable. The United States Government and the Trinity House have carried out exhaustive experiments in this direction, but the only result has been to accentuate our knowledge of the difficulties and the dangers entailed by fogs: we are as far as ever from any information that would help us to deal with them. Perhaps an examination into temperature conditions in the atmosphere, from the sea surface upwards, might be of use in throwing light on this difficult subject.

Ice.

The rapid growth of steam-ship navigation and the opening of the Suez Canal did much to minimise the dangers of floating ice, which was formerly a constant menace to sailing ships in high southern latitudes. The spread of civilisation, however, into higher northern latitudes, and the necessity for opening ice-bound ports, have again directed attention to the matter of ice-flows. Russia is seriously inconvenienced by the ice in her Far Eastern ports, and it is likely that we shall shortly find ourselves hampered in a like manner in the navigation of Hudson's Bay. Conflicting statements are made as to ice-bound ports, which at one time are reported open, and immediately afterwards, closed. What happens is, probably, this: ice accumulates to a certain point, then a change of current or a wave of milder temperature loosens the ice, so that it comes away from the land in great masses, and for a short time a presumably ice-closed port may be quite open.

Electrical Phenomena.

The connection between meteorological conditions and the formation of electrical phenomena, such as Aurora and St. Elmo's Fire, is uncertain; in many cases Cirrus clouds act, I believe, as leads for the electricity in those aerial displays. Masts of ships offer excellent points for the observation of electrical phenomena at sea. I have twice witnessed St. Elmo's Fire playing round the mast-head in bad weather; the effect was weird and striking. The subject is most interesting and deserves thorough investigation.

III.

In taking note of the meteorological work accomplished in different countries, we find the United States of America well to the fore. Captain Maury's labours have been followed up, and, thanks to the liberal financial support of the Government, the Department of the U.S. Hydrographic Office pursues its investigations in great measure untrammelled by any question of expense. The Office publishes details of all work done, so that the public are kept informed of the progress made. Since 1884 the Washington Hydrographic Office has issued monthly *Pilot Charts of the North Atlantic*, as well as of the *North Pacific* since 1894. These charts are furnished each year with additions and improvements. In addition to meteorological matter, navigational problems are usually printed on the face and back of these charts. The United States

Government is indefatigable in collecting knowledge beneficial to seamen. America has fitted out various expeditions for the exploration of the sea in all scientific aspects. Experimental meteorology is encouraged as much as possible; the Hydrographic Office issues handy note-books for the use of observers at sea. In the recent war with Spain, the Weather Bureau, under the able direction of Prof. Willis L. Moore, kept the fleet in the West Indies constantly supplied with weather forecasts.

England.—Considering the very limited funds at its disposal, it is surprising how much work is accomplished by the English Meteorological Office. Though a large proportion of the time at the Office is spent in the the routine work of issuing Daily Weather Charts, the list of publications in Appendix shows that research work is very energetically pursued. Since 1901 the Office has issued *Monthly Pilot Charts of the North Atlantic and Mediterranean*, which successfully furnish sailors with much useful information. The Office is at present engaged in the preparation of daily Atlantic weather charts, but is so far unable to issue them to the public. In 1889 the results of the *Challenger* Expedition, which had been very ably put together by Dr. A. Buchan, F.R.S., were published. This vast collection of reliable data marked an era in oceanic meteorological research; it is unlikely that any future work of the sort will do more than develop or enlarge the information contained in this publication. The present Antarctic Expeditions are devoting special attention to the meteorological conditions of Antarctic seas, with, we confidently expect, considerable success.

In *Canada*, *Australia*, and *New Zealand* meteorological research has been almost entirely confined to the taking of observations on land. At Sydney, however, Mr. H. C. Russell, F.R.S., applies himself to the study of ocean currents: he conducts his experiments chiefly with floating bottles: the work has been very successful. Commander M. W. C. Hepworth, C.B., R.N.R., the present Marine Superintendent at the Meteorological Office, has done much to assist Mr. Russell's labours.

In the *West Indies* the United States undertakes the meteorological investigations.

The Government of *India* interests itself specially in the study of the Monsoons: every effort is made to determine the origin and progression of these phenomena. In 1889 the late Mr. H. F. Blanford, F.R.S., published a valuable work on the *Climates and Weather of India*. From time to time the Government issues memoirs on the climatic conditions of the surrounding seas. The Meteorological Department is excellently organised, and does good work in different directions.

In *Hong Kong* Dr. Doberck has been occupied for years in the observation of cyclones in the Eastern Seas: this matter has also received much attention from the Spaniards, and latterly from the Americans, in the Philippines; and from the Japanese, in the Japanese Seas. The Spaniards collected much interesting information, which, however, being published in Spanish only, has been little noticed by foreign meteorologists.

Germany is untiring in the acquirement of meteorological knowledge. The Atlases of Ocean Meteorology issued by the Deutsche Seewarte are most excellent. This institution also publishes North Atlantic Pilot Charts. Germany has sent out many expeditions for the purpose of sea exploration.

Denmark associates itself with Germany in meteorological work.

Holland, as might be expected from the country of so maritime a nation as the Dutch, takes great interest in ocean meteorology. Charts of the Indian Ocean were published in Holland in 1889; although these charts deal with but three months, they are remarkably complete and instructive. Much of our meteorological information from high southern latitudes was collected by the Dutch, whose sailing ships, as a rule, followed higher latitudes than others.

France.—The Hydrographic Department of the Minister of Marine undertakes meteorological work in France. Some excellent marine charts and other publications on the subject have been issued. A Frenchman, Mons. L. Teisserenc de Bort, was the first to collect data as to the amount of cloud present in the atmosphere over the globe. The Office keeps careful record of all ocean work, and memoirs on the subject are issued periodically. The recently established "Société d'Oceanographie du Golfe de Gascogne" is most active: it is specially devoted to the examination of meteorological conditions in and about the Bay of Biscay.

In *Austria* considerable interest is taken in maritime meteorological work: the subject, in connection with general oceanography, has to be studied by all officers of the mercantile marine in preparation for their examinations.

Russia pays particular attention to land meteorological investigations, which are conducted in a very thorough manner. Colonel Schokalsky, Secretary of the Physical Section of the Imperial Russian Geographical Society, courteously informs me that Russia has recently issued wind charts of the Japanese Seas, and is at present engaged in investigations in the Black Sea and other Russian waters: these labours are conducted by the Hydrographic Department of the Admiralty. Meteorological charts of the Japanese Seas, the Black Sea, and the Russian coasts generally have been issued since 1896.

Spain apparently does not publish its meteorological work; the science is, nevertheless, not neglected in that country. The San Fernando Royal Observatory collects ocean meteorological information for the use of ships, and issues storm warnings. The Director of the Observatory, Señor T. de Azcarate, kindly gave me this information.

With the exception of *Japan*, other countries are not yet much interested in this branch of the science. The Meteorological Society of Japan has already issued papers dealing with oceanic aspects, and doubtless, before long, we shall find that energetic country doing useful work in the North Pacific.

The recent formation of an International Council to deal with the exploration of the sea, chiefly in the direction of the development of fisheries, will probably exert an immense influence on the furtherance of local meteorological work.

The Meteorological Office kindly prepared a chart (Fig. 1) for me showing the dispositions of places from which observations have been obtained: there remain many areas from which no observations whatever are forthcoming; it is to be hoped that seamen, who now often follow unfrequented tracks, will do what they can to supply these deficiencies.

Proportion of Meteorological Data over the Ocean.

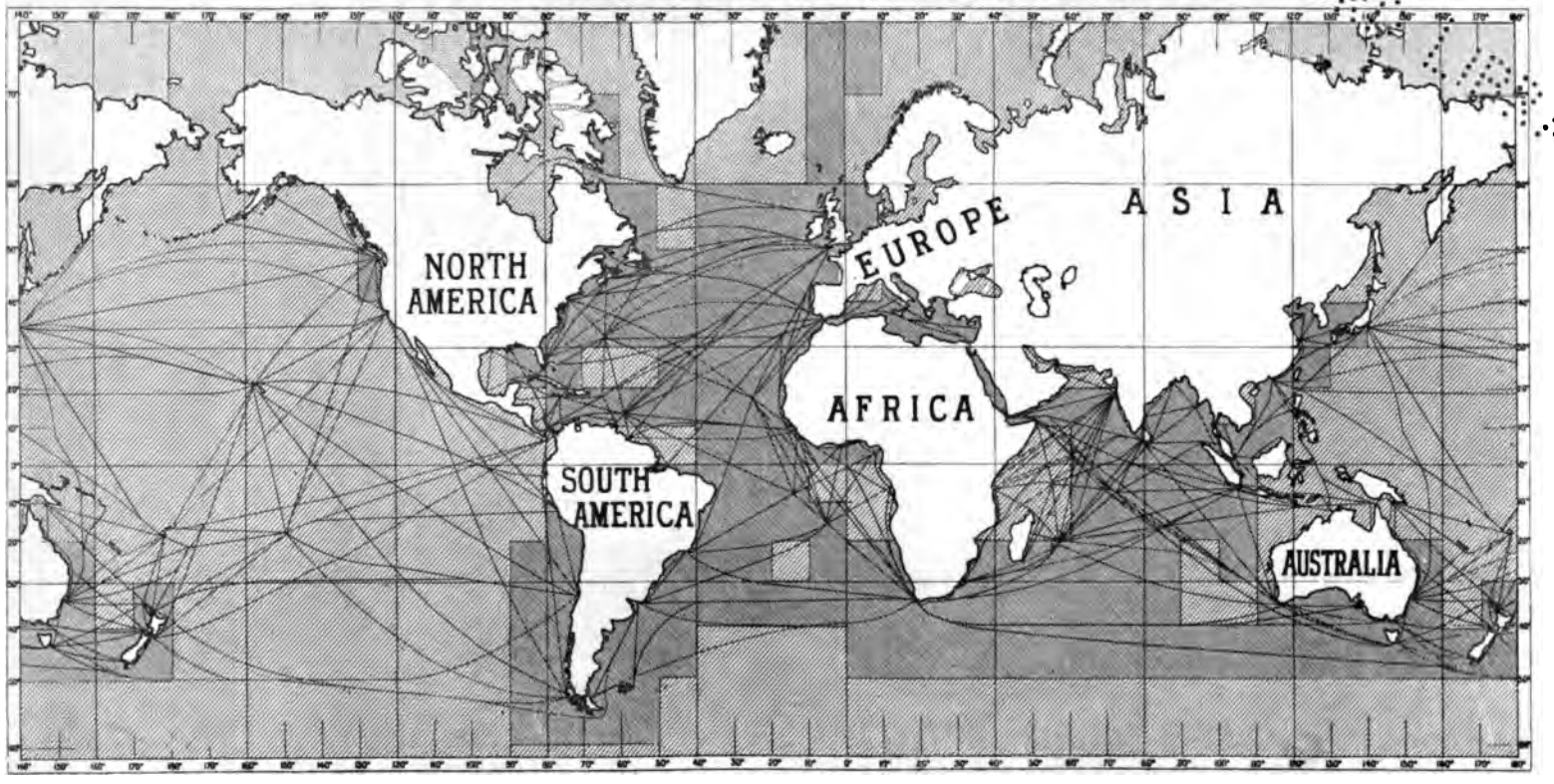


Fig. 1.

The establishment of a well-equipped observatory on an ocean island would be of the highest value for meteorological investigations; so, in a still greater degree, would be synchronous observations taken all over the globe, but it will be long, unfortunately, before we can hope to reach that development. Wireless telegraphy will doubtless play its part in the future of Meteorology.

IV.

I have tried to emphasise the importance of sea work, and have pointed out the facilities which sailors, rather than others, have for this branch of study. Their profession necessitates acquaintance with weather phenomena. Their open-air life, night and day, is offering them continual opportunities for improving their knowledge in this direction. They have an entirely unobstructed all-round view of sea and sky, and many phenomena which might pass unnoticed on land, must attract attention at sea. The study of the weather is important to the warship as well as to the merchant-ship, as was pointed out by Capt. M. W. C. Hepworth, in a paper read at the Royal United Service Institution.

Unfortunately, the usual method in meteorological research, so far, has been to confine attention to local areas, paying small heed to the greater movements perpetually going on outside and around these areas. The better plan is, I think, to work down from the greater phenomena to the less, piecing in our small scraps of knowledge as we go. To correctly solve any meteorological problems we must be quite clear as to the main conditions. In dealing with horizontal phenomena we do not encounter many difficulties; vertical extensions are the puzzle. It will probably take years of kite and balloon experimenting before we can form a working hypothesis of vertical air currents. Investigations are wanted in the air of the extreme high regions of the atmosphere: it may be that this air is of a different nature to that of lower levels. In the open spaces round the poles there is a free air circulation, and the barometer stands lower there than elsewhere on the surface of the globe. If no land surfaces intervened, this condition would probably be universal, but the vast land masses, particularly in the northern hemisphere, introduce complicating obstructions in the air path, which materially modify the conditions: the free sweep of the wind currents round the globe is blocked and diverted, first by the American continents, then by the Eurasian-African group of continents. If one watches the flow of the stream in a river, or the whirling of dust on a roadway, one sees an analogy of the effects produced by the barriers encountered by the atmospheric movements in their path; for, although the eddies in a stream and the whirls on a roadway are the results of comparatively insignificant causes, the accumulation of such obstructions develops striking and interesting phenomena.

We seem to have reached the limits to which it is possible to attain in weather forecasting with the meteorological knowledge within our reach. What we now require is a liberal infusion of scientific imagination into our midst, a bold striking-out in all directions to grasp the laws which certainly control and direct the, to us, apparently erratic, uncertain movements of meteorological phenomena. The official mind is unable

to make unusual departure from recognised scientific methods; but amateurs are freer from the bonds of tradition and routine. Let us hope that a meteorological Darwin will come forward to set us once for all in the path for which we are groping. I think something might be done to induce schools and colleges to make Meteorology a separate study; at present it comes in for the smallest possible notice as a branch of physiography, and no effort is made to engage the attention of the youthful intellect.

There are many meteorological questions awaiting reply; such as, the wherefore of the high barometric pressures on the polar east side of the oceans; why cyclones are specially prevalent in one region and not in another. Are the constituents of the extreme upper atmosphere similar to those of the lower air, or do they alter as we ascend? What would be the effect of such difference of constitution on the optical properties of the atmosphere, particularly when, as in the case of such eruptions as Krakatoa and Mont Pelée, quantities of gas are projected far into the upper atmosphere? Such phenomena as have been noticed are attributed to the presence of earth dust; but is this the true explanation? In comparing barometric heights, are we correct in reducing them all to sea-level instead of to an intermediate depth?

In the preparation of this Address I have been assisted by information kindly supplied by M. le Capitaine A. Roullin, Chef du Service de la Météorologie Nautique, France; M. le Capitaine Mazelle, Director J. R. Osservatorio Astronomico-Meteorologico, Triest; Colonel J. Schokalsky, Imperial Russian Navy, Société Impériale Russe de Géographie, St. Petersburg; and by the Meteorological Office. I have specially to thank Captain M. W. C. Hepworth and Mr. R. G. K. Lempfert for their courtesy in the matter.

I am very conscious of the extremely sketchy, superficial, and I fear I must add dry nature of this survey of a wide subject, but it may be, at all events from some points of view, that a rough, all-round approximation is more satisfactory than would be any attempt at minutely detailed information. The predominant feature of meteorological science to-day is still its all-pervading uncertainty. It is essentially a science in transition, and we can but hope that it will presently emerge from the region of shadows, to shed on us the full light now so tantalisingly obscure.

APPENDIX.

Bibliographical List of some of the Works bearing on the Meteorology of the Sea published between 1886 and 1903.

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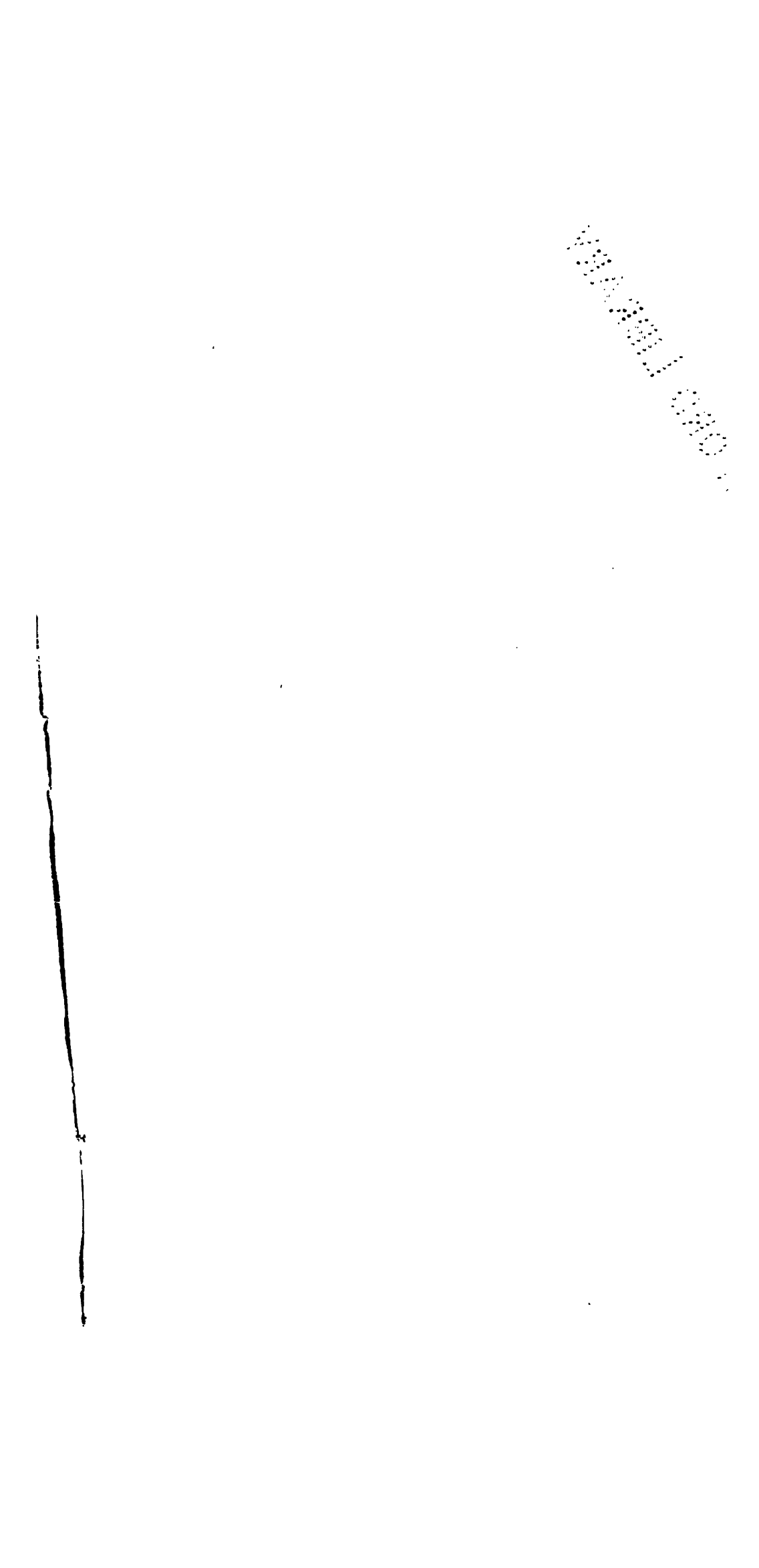
Proposed Pilot Charts of the South Atlantic and of the South Pacific Oceans.—According to a notice published in the United States *Pilot Chart* for January 1904, the United States Hydrographic Office has in view the publication of meteorological charts of the South Atlantic and of the South Pacific Oceans, similar in scope to the present *Monthly Pilot Charts* of the North Atlantic and North Pacific Oceans.

The proposed charts will be published quarterly instead of monthly, the first to appear being the chart of the South Atlantic Ocean for its winter months of 1904. It is hoped to have this ready for distribution, June 1, 1904.

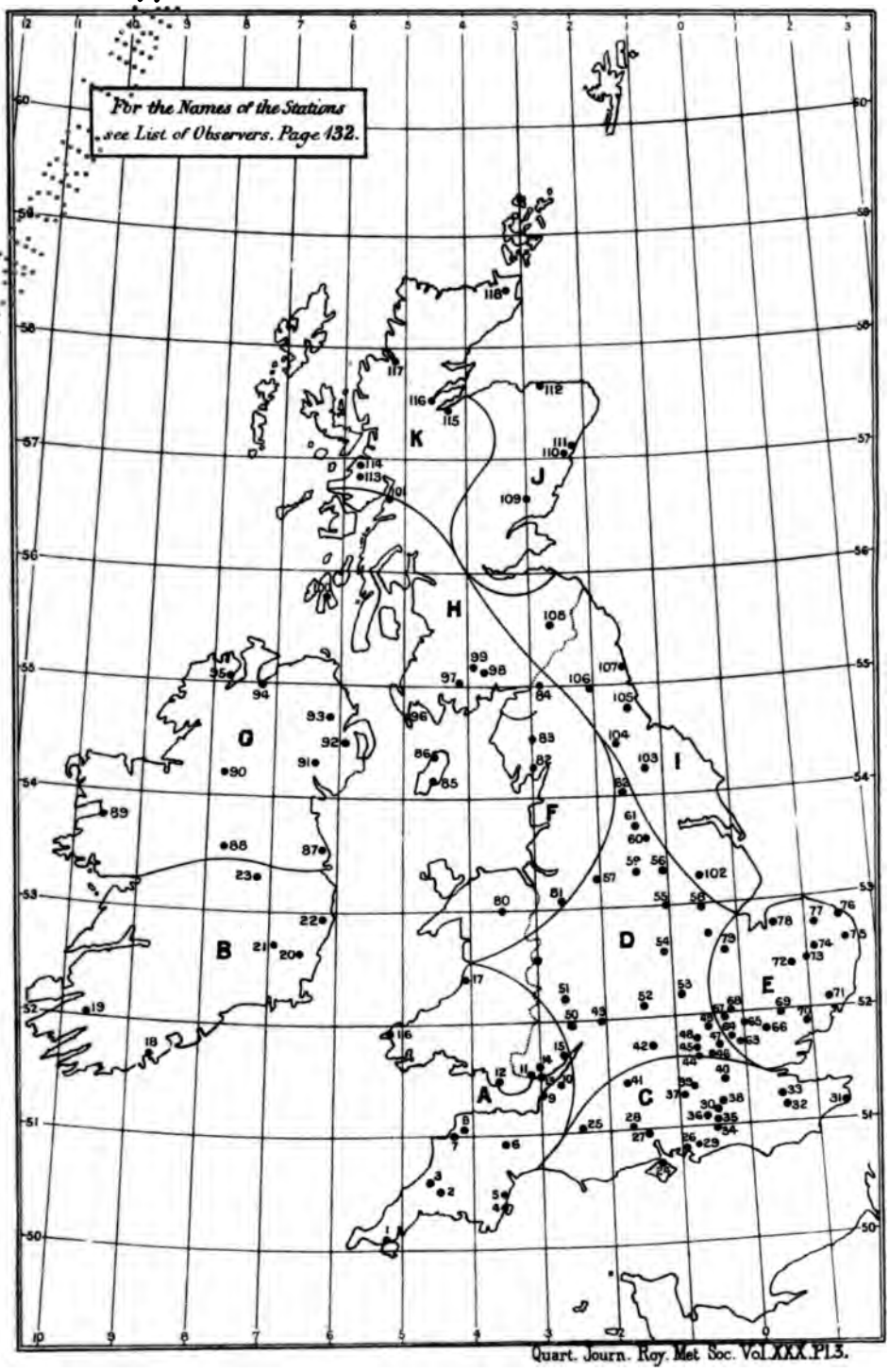
Successive seasonal charts of the South Atlantic Ocean will appear at quarterly intervals until the entire year has been included, after which a like series will be taken up for the South Pacific Ocean.

The United States Hydrographic Office earnestly requests the co-operation of mariners navigating these waters in the preparation of these charts. The assistance of masters of sailing vessels is especially desired. Blank forms for meteorological observations, with instructions for taking the same, will be furnished upon application either by mail or in person to the Hydrographer, United States Hydrographic Office, Navy Department, Washington, D.C., or to any one of the branch offices.

The charts will be furnished free of charge to co-operating observers, irrespective of nationality.—*Monthly Weather Review*, November 1903.



MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1903.



Quart. Journ. Roy. Met. Soc. Vol. XXX. Pl. 3.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1903.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

(Plate III.)

[Read February 17, 1904.]

The following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Tresco in District **A**; Winterfold in District **C**; St. Albans (Kitchener's Meads), Ullenhall, Thornhaugh, and Churchstoke in District **D**; Wenden in District **E**; Sulby in District **F**; Monaghan and Enniskillen in District **G**; Dumfries in District **H**; Willington in District **I**; and Edinburgh, New Mill, and Cullen in District **J**. On the other hand, new stations have been started or old ones revived, at Paignton in District **A**; Bagnalstown in District **B**; Staplehurst and Maidstone in District **C**; Sheffield (Ashgate Road) in District **D**; Scaleby in District **F**; Chanter Hill in District **G**; East Layton in District **I**; and Fordyce in District **J**. The total number of observing stations is now 118.

TABLE I.—Mean Results, with their Variations from the 12 Years' Average (1891-1902), for the Thirteen Plants in those Districts where there have been sufficient Observations to warrant Comparisons being made.

Years.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+ 10	144	+ 9	150	+ 11	147	+ 11	150	+ 7
1892	139	+ 5	138	+ 3	144	+ 5	143	+ 7	147	+ 4
1893	118	- 16	122	- 13	125	- 14	123	- 13	128	- 15
1894	126	- 8	130	- 5	135	- 4	127	- 9	137	- 6
1895	139	+ 5	138	+ 3	141	+ 2	138	+ 2	144	+ 1
1896	125	- 9	128	- 7	132	- 7	130	- 6	134	- 9
1897	130	- 4	132	- 3	136	- 3	132	- 4	142	- 1
1898	133	- 1	135	0	138	- 1	136	0	141	- 2
1899	136	+ 2	136	+ 1	141	+ 2	138	+ 2	145	+ 2
1900	142	+ 8	141	+ 6	144	+ 5	143	+ 7	152	+ 9
1901	138	+ 4	139	+ 4	141	+ 2	139	+ 3	144	+ 1
1902	139	+ 5	140	+ 5	145	+ 6	142	+ 6	152	+ 9
1903	134	0	134	- 1	137	- 2	134	- 2	145	+ 2
Mean	134	...	135	...	139	...	136	...	143	...

Explanation of the Dates in the Tables.

1- 31	are in January.	182-212	are in July.
32- 59	,, February.	213-243	,, August.
60- 90	,, March.	244-273	,, September.
91-120	,, April.	274-304	,, October.
121-151	,, May.	305-334	,, November.
152-181	,, June.	335-365	,, December.

The averages with which the mean dates of the different plants are compared in Table IV. have been obtained from the actual observations made during the 12 years 1891-1902 in all those districts where sufficient observations were available. Those for the remaining districts are as near approximations to the true averages as the limited number of records will allow.

The Winter of 1902-3.

This proved everywhere a warm winter, and more particularly was this the case in February, when the departures from the average in mean temperature ranged from + 3°·2 in the south of Ireland and the north of Scotland to + 5°·2 in the midland and north-eastern counties of England. The rainfall was exceptionally heavy in Scotland, above the average in Ireland and the north-west of England, but in all the other English districts less than a seasonable quantity of rain was deposited. Throughout the greater part of the British Isles there was a marked deficiency of bright sunshine.

So favourable had the weather been during October and November that little remained to be done in the way of sowing autumn corn after the winter began, and as the ground continued for the most part warm for the season the grain as a rule germinated quickly and regularly. In the same way the preparation of the land for the spring crops could be proceeded with during the winter months with only occasional interruptions from frost or the saturated condition of the ground. At all events such was the case throughout the greater part of England, but in Scotland and Ireland tillage operations were, unfortunately, much impeded by frequent and heavy rains, and it is a wet, rather than a severe, winter which is most to be dreaded by agriculturists. Those English farmers who took advantage of the fine and dry weather in February were able to provide their spring corn with a more satisfactory seed-bed than was possible at any time afterwards. Although a very mild winter, there occurred during the course of it two frosts which lasted sufficiently long to keep the young crops from becoming dangerously forward. For the cattle and sheep this was on the whole a favourable winter, as there was in most districts a plentiful store of hay and roots, while the grass remained unusually green for the time of year in the pastures.

In the kitchen garden the green vegetables had made such good, but unusually succulent, growth during the cool summer and warm autumn of the previous year, that it was fortunate that the winter which followed proved on the whole so mild. Owing to the keen frost which occurred at the beginning of December there were fewer survivals from the autumn than in recent years to be found in the flower garden during that month. On the other hand, the winter aconites, snowdrops, crocuses, and other winter-flowering bulbs, came into blossom unusually early in January and February.

Many thousands of trees in Ireland, and in the north-west of England and west of Scotland, were blown down by the gale of February 26-27, described by Dr. W. N. Shaw, F.R.S., at the last June meeting of the Society.

The fertile flowers on the hazel made their appearance, taking the

country as a whole, 5 days earlier than usual, while the coltsfoot was 7 days early.

The song-thrush was first heard after the beginning of January, 8 days in advance of its average date.

The honey-bee visited flowers 13 days before its usual time.

The Spring.

Taken as a whole, the spring was of about average temperature, March being the warm, and April the cold month of the season. In all districts the fall of rain was in excess of the mean, while scanty records of sunshine were equally general. Altogether this was a wet and gloomy season.

Just as the sowing of spring corn was becoming general towards the end of February wet weather set in, so that it was only during the brief period of dry weather in March that any progress at all was made. Fortunately, with the advent of April a change to drier conditions took place, and before the middle of that month the land became sufficiently workable to allow of a large area being sown with corn and mangold. The sowing period for corn was in most parts of the country very late, and lasted altogether over three months. Moreover, it was only in February that an altogether satisfactory seed-bed was obtainable, so saturated did the ground become afterwards owing to the frequent and heavy rains in March and at the end of April. At the close of the season the cereals, favoured by the warm and dry weather of the last 10 days in May, presented on the whole a fairly promising appearance. Gaps in the rows were, however, here and there visible owing to faulty planting and the injuries inflicted by wireworm when the growth remained stationary during the long spell of cold weather in April. Potatoes were planted under difficulties owing to the saturated condition of the ground, and in many places the young shoots were blackened by the keen frosts which occurred in the middle of that month. The grass in the meadows, assisted by the heavy rainfall at the end of April and the beginning of May, and afterwards by the warm weather at the close of the latter month, grew rapidly, while throughout the spring there was always a full crop of herbage in the pastures. The great drawbacks of the season were the saturated condition of the ground, the paucity of sunshine, and as regards vegetation generally, the long period of night-frosts and cold winds in April. In the north of England, Scotland, and Ireland the sowing season is said to have been one of the latest on record.

As was the case in the fields so was it in the garden, for it was only during the brief period of suitable weather that the preparation of the ground for seed sowing was possible, especially on heavy soils, owing either to the wet or frozen condition of the surface soil. The fruit trees flowered unusually early, and the blossom was in most districts abundant. Indeed, all went well until nearly the middle of April, when almost the whole of the fruit blossom was in most places destroyed by the keen frosts and cold winds which followed. The cold period referred to lasted altogether about a fortnight, and appeared from the reports of the observers to have been general throughout the whole of the British Isles.

The April frosts also did considerable damage in many places,

not only to the hawthorn and horse-chestnut blossom, but also to their young foliage, while many other hardy trees and plants were also similarly affected.

The first three plants on the list flowered earlier than usual, the wood anemone being 6 days early, the blackthorn 6 days early, and the garlic hedge mustard 6 days early. Then came the severe April

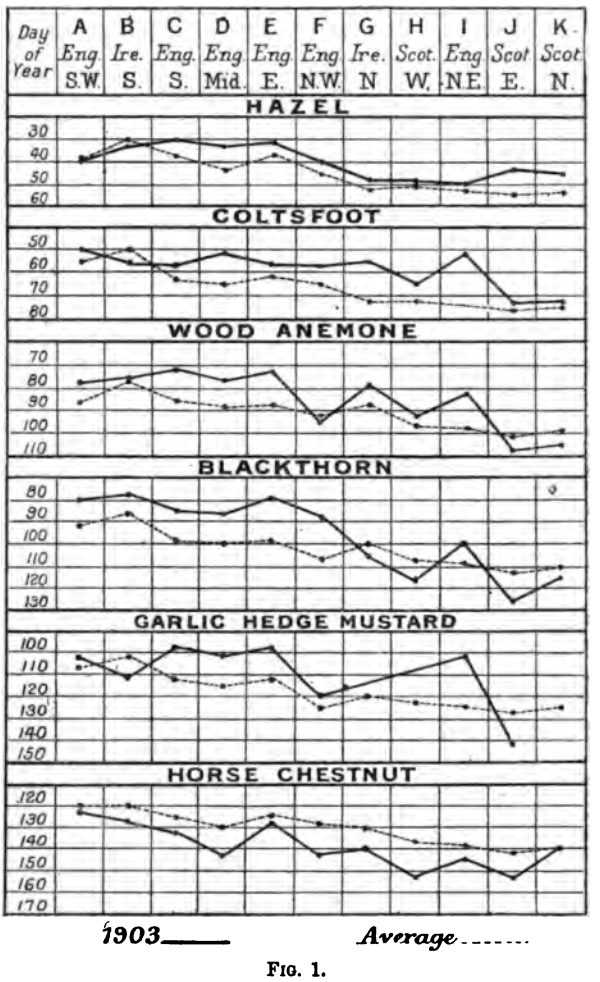


FIG. 1.

frosts which checked the advance of vegetation considerably, so that the horse-chestnut was 7 days late, and the hawthorn 1 day late. The late date with which the horse-chestnut is here credited was no doubt in some measure brought about by the way in which so many horse-chestnuts suffered in flower and foliage from keen winds during the cold period in April.

All the spring migrants on the air were singularly late in making

their appearance, the swallow being 4 days late, the cuckoo 6 days late, the nightingale 7 days late, and the fly-catcher 6 days late. The mean dates for the cuckoo and nightingale are the latest yet recorded, *i.e.* since 1891.

All the spring insects appeared behind their usual dates, the wasp being 6 days late, the small white butterfly 12 days late, and the orange-tip butterfly 8 days late.

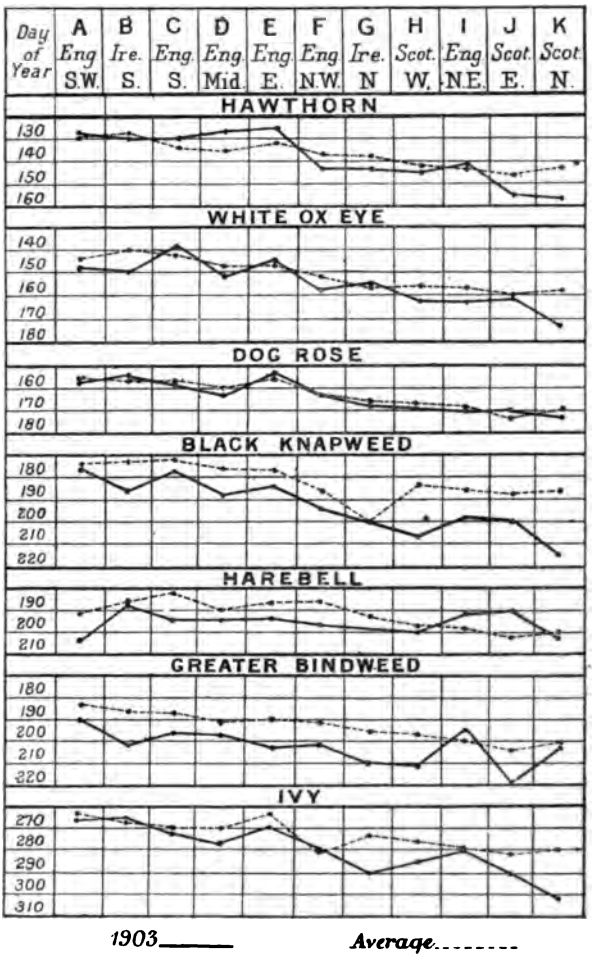


FIG. 2.

The Summer.

In each of the three summer months the weather continued cold. In July, however, the mean temperature was in most districts only slightly below the average. This was another wet season, the rainfall being unusually heavy in all parts of the country. It was also another cloudy season, but there was not quite such a striking deficiency in the sunshine records as in those for the winter and spring.

The first three weeks in June were cold and the rainfall at times singularly heavy, but at the end of that period a welcome change to hot and dry weather took place, which lasted nearly a month. This was the one drought of the year, and came opportunely for the hay, as it enabled the greater part of a very heavy crop to be harvested with scarcely any trouble, and in perfect condition. A good deal of hay had, however, been cut in the earlier districts before the change to dry weather took place, and was consequently much damaged. At the time when these heavy rains were falling in the southern and midland counties of England, the farms in the extreme north of England, and also those in Scotland and Ireland, were suffering from a long spell of cold and dry weather, which checked the growth of the grass. Consequently the hay crop was there, by comparison, small and much of it harvested under very adverse conditions when a return to wet weather took place later on in the season.

The cereals, which had previously made but slow progress, greatly improved when the warm and dry weather set in, and it was fortunate that their fertilising period occurred when the atmospheric conditions were thus favourable. The late-sown corn, however, after a time began to suffer from the effects of the continued drought, but quickly revived when the wet weather at last arrived. A good deal of the standing corn was in places beaten down and twisted by the heavy rain storms which occurred at the end of July and during August, and the damage done in this way was more than usual owing to the already sodden state of the ground. From the time reaping began in the early districts until the close of the season there was scarcely a day without some rain, so that very little corn had by that time been got in.

The dry weather at the beginning of June favoured the sowing of swedes and turnips, but when they came up they had a trying time during the dry period which set in later in the month, as the ground after the heavy rains in mid-June became hard and caked on the surface. In the south the grass in the pastures remained fresh and green throughout the summer, but in the north of England and in Scotland the dry weather in June caused them to become for a time dry and bare.

The only really genial and growing time for garden produce was the spell of warm and dry weather which lasted from about midsummer day until the middle of July.

All the summer-flowering plants on the list, except the dog rose, which flowered at its average time, were late in coming into blossom, the white ox-eye being 4 days late, the black knapweed 11 days late, the harebell 3 days late, and the greater bindweed 9 days late.

The meadow-brown butterfly made its appearance 9 days later than usual.

The Autumn.

The last quarter of the phenological year was more or less warm throughout—October being the most unseasonably warm month of the three. In all parts of the United Kingdom the fall of rain was in excess of the average, and especially was this the case in October, when the departure from the mean ranged between + 1·5 in. in the south of Ireland and + 4·7 ins. in the west of Scotland. The distribution of clear sunshine

was irregular. In September and November the duration was generally in excess of the mean, but in all districts there were scanty records during October.

A good deal of corn was harvested in the earlier districts during the first week in September. Then came a week of wet weather when little could be done. It was, however, during the dry third week of that month that the greater part of the grain crops in the southern half of England were got in. In the later districts of England, as well as in Scotland and Ireland, the outlook was at first more promising than it had been elsewhere, but soon after reaping began there rain again set in, and there was little fine weather afterwards, so that in the early, middle, and late harvest districts alike the weather was almost equally unfavourable. If the conditions had been unpropitious in August and September they proved altogether hopeless in October, for in that month there occurred virtually no intervals of dry weather at all. Of course, under such adverse circumstances it was the backward districts that suffered the most. In fact, as late as the middle of October nearly half the corn in Scotland, as well as that in the north of Ireland, still remained uncut. With November at last came a change to fine weather which was everywhere warmly welcomed, as it then became possible to gather in the belated corn left in the fields; much of it was, however, harvested in very indifferent condition, owing to its long exposure to the incessant rains of the previous month. It was strange to see in the month of November, and in some places even as late as December, corn standing in shock here and there in the fields throughout the whole of the British Isles. Taking the country as a whole, but a small portion of the corn crop appears to have been at any time gathered in really good condition. The turnips, swedes, and mangolds improved greatly during September, but the wet weather in October after a time proved too much for even those moisture-loving roots. Towards the end of the summer the potatoes began to show signs of disease which increased rapidly as the autumn advanced. Seldom have potato tubers been as generally, or as seriously, affected. Indeed, in many cases the crop was not worth lifting. The second yield of hay suffered as much as the corn during this season, but on the other hand, where the land was not flooded, there was always plenty of grass in the pastures. To add to the disasters of this trying season, what with the saturated condition of the ground and the unusual length of time which had to be given to the ingathering of the corn and roots, there were few opportunities after the middle of September, until about the middle of November, of cultivating land for winter corn. As is usual after such a wet and cool summer, weeds were everywhere in evidence, and added considerably to the farmer's trials.

In the garden the autumn-flowering plants were late in blossoming, but after the middle of September there was an unusually good show of bloom, and especially was this the case with dahlias and roses. The winter supply of green vegetables, favoured by the wet season, was all that could be desired; but the root-crops, owing to the same cause, made unusually good growth above ground at the expense of that beneath the surface. The planting of fruit and other trees and shrubs was much delayed by the saturated condition of the soil.

The thorough soaking to which the subsoil had been subjected during the year, together with the cool summer, greatly benefited the timber trees, which have not for some years presented such a luxuriant appearance, or made such good growth. Blackberries were surprisingly plentiful, but most of the other wild fruits were less numerous than usual. The gale which occurred on September 10 did much damage to trees in the south-west and southern districts of England. Insects of all kinds, using the term in its popular sense, were by no means as well represented as usual. At the end of September and beginning of October the painted lady butterfly made its appearance in unusual numbers along the east coast of England and Scotland, as well as in other parts of England. These butterflies are thought to have come over from the Continent during the spell of warm weather which occurred at that time.

The only autumn plant on the list, the ivy, came into flower 6 days later than usual.

The mean date for the departure of the last swallow was 1 day early.

According to the *Preliminary Statement for Great Britain*, issued by the Board of Agriculture, the yield of wheat was below the average for the previous 10 years by 0·40 bushel per acre, barley by 0·83 bushel, turnips and swedes by 0·45 ton, and potatoes by 0·73 ton per acre. On the other hand, oats exceeded the average by 1·05 bushel per acre, beans by 4·12 bushels, peas by 0·66 bushel, mangolds by 0·11 ton, hay (permanent pasture) by 3·26 cwt., and clover, etc., by 2·48 cwt. per acre. The yield of beans has only twice been exceeded during the last 20 years. It is truly surprising, considering the adverse weather conditions, how good the yield of farm crops, on the whole, comes out. The only favourable circumstances appear to have been the excellent planting time for wheat in October 1902, the short spell of good weather for sowing spring corn in February, and the splendid change to warm and dry weather between the middle of June and the middle of July. No doubt, however, the previous long series of dry years, by draining the subsoil, must have formed a considerable factor in bringing about these unexpectedly favourable results. Whatever may have been the contributory causes, one thing remains certain, and that is, that the year 1903 must be ranked as one of the most disastrous to the arable farmer known for some years, on account of the damaged quality of the grain crops and of the potatoes.

In order to show the very unfavourable character of the sowing period in the spring, it may be stated that the total area sown with barley in Great Britain was the smallest during the 35 years covered by official records; and the same must be said of swedes and turnips. There was also a diminished area planted with mangolds as compared with the previous year in every county of England except Rutland.

Taking the British Isles as a whole, the corn harvest began 8 days later than the average date for the previous 14 years.

The yield of fruit was most exceptionally scanty. The crops of apples, pears, and plums were in all parts of the kingdom considerably under average, while raspberries, currants, and gooseberries were also very deficient. Indeed, the only crop which was in any way over average was that of strawberries. I extract the following remark from a leading article in the *Gardeners' Chronicle* of August 1:—"Never since

we have made a practice of recording the condition of the fruit crops, a period of nearly forty years, have we had occasion to present so disastrous a record. From John o' Groats to the Land's End, from Galway to East Anglia, the tale is the same."

The Year.

Taken as a whole, this was a warm, very wet, and sunless year. As affecting vegetation, the most noteworthy meteorological features were the severity of the April frosts, the three weeks of dry, warm, and sunny weather which occurred towards the middle of an otherwise cold, rainy, and gloomy summer, and the excessive and persistent rainfall in October. Owing to the mildness of the winter and early spring, wild plants flowered in advance of their average dates until about May, after which time only backward dates were recorded. In no previous year since the present series of reports were first instituted in 1891 have such spring migrants as the swallow, cuckoo, and nightingale been so late in reaching our shores. The yield of wheat, barley, potatoes, turnips, and swedes was somewhat under average, but all the other farm crops yielded well, especially those of hay and beans, which were unusually abundant. On account of the wet and protracted harvest most of the grain of cereals was more or less discoloured, while potatoes were almost everywhere much diseased. This was throughout the country one of the most disastrous years for fruit ever known. In fact, the only crop which gave anything like an average yield was that of strawberries.

OBSERVERS' NOTES.

DECEMBER 1902.—*Altarnon* (A)—31st. A good season for snipe and woodcock. *Churt Vicarage* (C)—25th. Ten kinds of flowers out in garden, which are fewer than usual. *Bayshot* (C)—6th. The oak leaves have all fallen. *Lake Side* (F)—27th. Primroses in flower in the woods.

JANUARY 1903.—*Mawnan* (A)—29th. Gathered a bunch of primroses in a wood. *Bridgend* (A)—26th. Woodpecker first heard.

FEBRUARY.—*Mawnan* (A)—22nd. Dusty rain, which made windows very dirty. *Altarnon* (A)—A grand seed-bed for early beans and peas. 22nd. Dust storm, water dirty in rain-gauge. *St. Arvans* (A)—12th. A bunch of primroses picked in the woods. 22nd. The rain left a coating of sandy dust on the windows, etc. *Skibbereen* (B)—26th. Violent storm at night, which uprooted many of the largest trees in the district. *Ovoca* (B)—26th. Hundreds of trees blown down by the gale. *Geashill* (B)—26th. Many trees blown down in the Rectory grounds. *Berkhamsted* (D)—17th. The grass so dry on railway embankment that a spark from the engine set fire to it. *Palé* (F)—26th. Many trees uprooted by the storm. *Lake Side* (F)—26th. Fierce gale. Trees torn up by the roots. The storm was so violent that the windows here eight miles from the sea were covered with salt and sand. The foliage of some shrubs destroyed by it. *Scaleby* (F)—26th. Heavy gale. *Cronkbourne* (F)—26th. A severe storm; eighteen Austrian pines blown down here. *Ardgillan* (G)—26th. A hurricane during the night. *Jardington* (H)—The grass as green as in April or May. *Moniaive* (H)—The grass made unusual growth for the time of year. *Thirsk* (I)—Everything apparently as forward as in an average April. 26th. A fierce gale, which snapped off trees by the roots and tore away huge branches.

TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
A			
1. Mawnan	Cornwall	200	Miss R. Barclay.
2. Liskeard	Cornwall	400	S. W. Jenkin, C.E.
3. Altarnon	Cornwall	600	C. U. Tripp, M.A., F.R.Met.Soc.
4. Brixham	Devon	40	F. W. Millett.
5. Paignton	Devon	70	Miss M. Waite.
6. Tiverton	Devon	270	Miss M. E. Gill.
7. Westward Ho	Devon	130	Miss Patterson.
8. Barnstaple	Devon	90	T. Wainwright.
9. Sidcot	Somerset	200	W. F. Miller.
10. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11. Penarth	Glamorgan	120	G. A. Birkenhead.
12. Bridgend	Glamorgan	90	H. J. Randall, Junr.
13. Castleton	Monmouth	80	The late F. G. Evans, F.R.Met.Soc.
14. Little Mill	Monmouth	300	W. J. Grant, F.R.H.S.
15. St. Arvans	Monmouth	360	Miss M. Peake.
16. St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
17. Aberystwith	Cardigan	30	J. H. Salter, D.Sc.
B			
18. Skibbereen	Cork	30	J. J. Wolfe.
19. Killarney	Kerry	100	Ven. Archdeacon Wynne, D.D.
20. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc., F.L.S.
21. Bagnalstown	Carlow	290	Miss F. S. Wynne.
22. Ovoca	Wicklow	110	Miss W. F. Wynne.
23. Geashill	King's County	280	Rev. Canon Russell.
C			
24. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
25. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
26. Havant	Hants	30	H. Beeston.
27. Botley	Hants	30	Lady Jenkyns.
28. Fordingbridge	Hants	90	S. Bramley.
29. Birdham	Sussex	10	A. J. Nixon.
30. Muntham	Sussex	250	P. S. Godman, F.Z.S.
31. Dover	Kent	150	F. D. Campbell.
32. Staplehurst	Kent	110	Rev. J. S. Chamberlain.
33. Maidstone	Kent	100	Mrs. Silcock.
34. Chiddingfold	Surrey	230	Admiral Maclear, F.R.Met.Soc.
35. Cranleigh	Surrey	180	Miss H. E. Ravenscroft.
36. Coneyhurst	Surrey	600	J. Russell.
37. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
37. Churt	Surrey	300	C. Criddle.
38. Oxshott	Surrey	210	W. H. Dines, F.R.Met.Soc.
39. Bagshot	Surrey	230	W. Burgess.
40. Weston Green	Surrey	30	H. T. Potter.
41. Marlborough	Wilts	480	E. Meyrick.
D			
42. Oxford	Oxford	200	F. A. Bellamy.
43. Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
44. Harefield	Middlesex	340	G. E. Eland.
45. Chesham	Bucks	300	Miss G. Keating.
46. Watford (The Platts)	Herts	240	Mrs. G. E. Bishop.
46. Watford (Weetwood)	Herts	270	Mrs. J. Hopkinson.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
47. St. Albans	Herts	300	H. Lewis.
48. Berkhamsted	Herts	400	Mrs. E. Mawley.
49. Harpenden	Herts	370	J. J. Willis.
50. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
51. Leominster	Hereford	220	J. H. Arkwright.
52. Farnborough	Warwick	520	Miss D. J. G. Prater.
53. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
54. Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
55. Beeston	Notts	210	G. Fellows.
56. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
57. Macclesfield	Cheshire	500	J. Dale.
58. Belton	Lincoln	200	Miss F. H. Woolward.
59. Sheffield (Endcliffe Rise Road)	Yorks (W.R.)	450	Miss E. F. Smith.
59. Sheffield (Ashgate Road)	Yorks (W.R.)	600	Miss Heatley.
60. Altofts	Yorks (W.R.)	120	H. G. Townsend.
61. Horbury	Yorks (W.R.)	210	W. Rushforth.
62. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
63. Broxbourne	Herts	120	Rev. H. P. Waller.
64. Hatfield	Herts	300	T. Brown.
65. Hertford	Herts	140	W. Graveson.
66. Sawbridgeworth	Herts	350	H. S. Rivers.
67. Hitchin	Herts	220	A. W. Dawson, M.A.
68. Odsey (Ashwell)	Cambridge	260	H. G. Fordham.
69. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
70. Lexden	Essex	90	S. F. Hurnard.
71. Sproughton	Suffolk	30	Rev. A. Foster Melliar.
72. Market Weston	Suffolk	150	Rev. E. T. Daubeney.
73. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
74. Tacolneston	Norfolk	190	Miss E. J. Barrow.
75. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
76. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
77. Hevingham	Norfolk	...	Major Marsham.
78. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
79. Peterborough	Northampton	30	J. W. Bodger.
F			
80. Palé	Merioneth	600	T. Ruddy.
81. Betley	Cheshire	370	Miss M. L. Hodgson.
82. Lake Side	Lancashire	210	Miss L. Burton.
83. Ambleside	Westmoreland	260	Dr. G. A. Johnston and Miss Armitt.
84. Scaleby	Cumberland	110	Rev. H. Allison.
85. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
86. Orry's Dale	Isle of Man	70	Miss C. M. Crellin.
G			
87. Ardgillan	Dublin	210	J. Woodward.
88. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
89. Westport	Mayo	10	J. M. McBride.
90. Chanter Hill	Fermanagh	250	Rev. Canon Ovenden.
91. Loughbrickland	Down	350	Rev. Canon Lett.
92. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
93. Antrim	Antrim	70	Rev. W. S. Smith.
94. Altnafoyle	Londonderry	450	T. Gibson.
95. Ramelton	Donegal	200	Miss K. Swiney.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station	County.	Height above Sea-level.	Observer.
H		Ft.	
96. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson.
97. New Galloway	Kirkcudbright	450	T. R. Bruce.
98. Jardington	Dumfries	100	J. Rutherford.
99. Moniaive	Dumfries	350	J. Corrie.
100. Port Ellen	Isle of Islay	10	T. F. Gilmour.
101. Duror	Argyll	20	R. Macgregor.
I			
102. Doddington	Lincoln	90	Rev. R. E. Cole.
103. Thirsk	Yorks (N.R.)	120	A. B. Hall.
104. East Layton	Yorks (N.R.)	570	Mrs. E. O. M. Proud.
105. Durham	Durham	350	Prof. R. A. Sampson and F. C. Carpenter.
106. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
107. Blyth	Northumberland	20	S. Dunnett.
108. Lilliesleaf	Roxburgh	530	Miss C. M. D. Sprot.
J			
109. Kirriemuir	Forfar	250	T. M. Nicoll.
110. Durris	Kincardine	420	A. Macdonald, M.A.
111. Aberdeen	Aberdeen	40	P. Harper.
112. Fordyce	Banff	80	J. Ingram.
K			
113. Invermoidart	Inverness	60	S. M. Macvicar.
114. Roshven	Inverness	40	H. Blackburn.
115. Beauly	Inverness	60	A. Birnie.
116. Dingwall	Ross	10	J. P. Smith, M.D.
117. Inverbroom	Ross	50	Lady Fowler.
118. Watten	Caithness	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations, Plate III.

March.—*Altarnon* (A)—Ground saturated by frequent rains and therefore unworkable. *Bridgend* (A)—23rd. Wheatear first seen. *Churt* (C)—Primroses have been in full bloom in woods since January 6th. *Watford* (*The Platts*) (D)—30th. Water-wagtails arrived. *St. Albans* (D)—6th. Willow-wren heard. *Berkhamsted* (D)—30th. A wild cherry tree in my garden in flower, or exactly three weeks earlier than its average date in the previous 17 years, and earlier than in any of those years. *Leominster* (D)—A remarkably early horse-chestnut on Aylestone Hill was in leaf on the 2nd. On April 1st it had large open leaves and a small cluster of flower-buds. *Brunstead* (E)—9th. Great many field-mice and field-voles in garden. 17th. Frog spawn first seen. *Thirsk* (I)—4th. Frog spawn first seen.

April.—*Altarnon* (A)—Early potatoes and the blossoms of apples, pears, plums, gooseberries, and currants suffered greatly from frequent frosts. *Tiverton* (A)—20th. The frosts of the past week did much damage to fruit-tree blossom and to potatoes. *Ovoca* (B)—In the middle of the month early potatoes and pear and plum blossom were badly damaged by frost. *Geashill* (B)—Frosts

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1903.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Mawnan	30	...	...	75	...	...	134	155	168	...	...	...	277
Liskeard	...	48	97	87	...	...	...	...	...	...	...	...	...
Altarnon	55	59	96	96	109	139	149	159	170	201	216	208	266
Brixham	63	60	...	71	...	109	128	...	156	...	...	191	261
Paignton	...	...	...	74	100	107	110	...	151	151	...	189	242
Tiverton	38	36	63	66	98	107	121	147	153	...	...	...	...
Westward Ho	57	*87*	87	92	123	130	133	151	...	184	...	205	291
Barnstaple	28	50	78	67	85	117	130	150	158	177	201	193	270
Sidcot	31	62	59	69	95	117	133	144	154	170	...	194	260
Clifton	...	...	...	93	...	118	120	...	...	...	...	...	268
Bridgend	43	58	78	88	101	135	139	149	157	163	207	177	280
Castleton	32	43	69	71	92	96	124	142	156	178	...	186	259
Little Mill	36	41	65	68	118	124	115	138	155	175	...	176	255
St. Arvans	26	49	...	...	...	125	135	152	156	...	...	...	259
St. Davids	...	50	...	107	...	125	138	153	...	170	...	178	...
Aberystwith	41	42	86	80	99	145	129	137	155	182	189	196	256
B													
Skibbereen	27	...	67	70	...	129	127	151	...	...	...	...	...
Killarney	38	62	69	72	103	95	116	154	156	199	181	195	252
Ferns	46	52	89	80	...	122	125	150	150	179	192	192	275
Bagnalstown	...	...	...	...	120	140	141	150	...	...	...	*230*	...
Ovoca	24	53	...	79	...	122	131	145	...	191	...	207	...
Geashill	...	...	...	87	109	142	138	...	158	175	...	211	268
C													
Bembridge	...	...	...	74	102	103	124	126	161	162	...	...	...
Buckhorn Weston	34	48	56	85	91	142	130	126	154	173	...	193	271
Havant	11	66	67	78	94	121	130	125	157	161	207	197	271
Botley	32	52	67	71	102	140	142	142	...	189	218	200	285
Fordingbridge	37	...	88	93	...	149	145	144	...	...	...	...	...
Birdham	43	62	...	82	97	108	111	142	153	174	...	*164*	281
Muntham	7	57	72	81	93	143	130	134	155	177	...	187	282
Dover	...	48	...	...	...	121	135	...	168	183	...	...	275
Staplehurst	26	49	66	72	82	111	112	134	146	...	...	194	265
Maidstone	45	50	68	85	97	118	113	135	140	178	...	...	264
Chiddingfold	30	42	60	83	96	130	130	144	159	172	203	194	269
Cranleigh	33	57	74	82	106	141	130	145	...	...	...	...	274
Coneyhurst	34	83	*106*	107	128	146	135	150	...	...	...	...	...
Churt Vicarage	29	...	83	89	94	141	140	147	156	174	163	205	...
Churt	4	83	71	*118*	88	137	135	128	*135*	*190*	171	206	271
Oxshott	43	59	...	99	102	133	129	...	164	...	...	...	...
Bagshot	37	...	85	89	...	133	124	124	159	174	...	196	278
Weston Green	30	57	81	81	95	137	137	138	170	174	...	191	261
Marlborough	23	60	51	88	99	143	140	157	167	207	200	191	260
D													
Oxford	...	...	...	...	...	144	137	153	161	...	209	210	265
Beckford	37	40	69	69	83	141	105	122	155	172	197	181	265
Harefield	...	...	95	87	...	139	134	150	158	...	...	206	...

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1903—*continued*.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Chesham	*15*	78	...	...	93	142	132	133	...	207	...	196	*301*
Watford (The Platts)	34	...	97	94	96	...	...	...	...	...	...	*230*	...
Watford (Weetwood)	36	69	78	88	91	137	123	146	153	188	...	...	264
Berkhamsted	45	49	84	88	105	141	143	145	157	...	199	194	283
Harpenden	38	50	89	81	99	139	140	152	156	...	...	...	...
Ross	31	44	64	63	81	113	104	...	157	...	...	...	269
Leominster	38	...	72	83	...	142	135	...	..	...	...	179	...
Farnborough	28	24	67	79	89	141	115	144	159	204	...	179	281
Northampton	38	48	48	74	101	141	133	152	162	176	195	200	266
Thurcaston	39	50	...	94	96	143	109	151	156	167	196	204	272
Beeston	32	55	...	84	118	...	119	163	175	185	161	...	...
Hodsock	31	54	67	74	99	107	121	156	157	188	198	177	278
Macclesfield	43	75	83	105	140	148	144	153	163	182	184	197	274
Belton	37	48	83	...	...	...	...	...	...	...	...	...	...
Sheffield (Endcliffe Rise Road)	43	49	57	...	...	141	139	161	186	200	204	202	306
Altofts	31	40	78	94	101	...	...	160	169	171	199	213	...
Horbury	39	49	80	...	98	...	116	171	...	211	...	214	311
Ripley	30	...	80	97	125	145	143	150	...	...	...	...	...
E													
Broxbourne	34	56	74	89	95	...	...	...	150	...	...	...	262
Hatfield	21	...	80	81	...	129	122	149	154	207	...	200	...
Hertford	32	53	67	61	95	126	119	148	154	179	197	207	277
Sawbridgeworth	36	79	82	81	98	...	...	...	...	...	...	...	...
Hitchin	...	...	...	...	...	...	122	...	152	...	203	...	268
Odsey (Ashwell)	2'	39	...	...	...	...	117	...	154	...	...	...	271
Bocking	26	66	...	...	...	118	125	156	153	195	...	229	270
Lexden	26	50	74	76	102	137	...	132	147	168	192	189	264
Sproughton	25	54	59	81	101	127	119	134	151	...	...	...	...
Market Weston	41	65	79	79	95	137	128	150	156	163	180	188	261
Carleton-Forehoe	47	62	...	86	99	124	130	149	162	155	...	...	261
Tacolneston	29	41	80	...	91	96	...	146	154	184	...	...	273
Brundall	43	...	64	84	90	128	120	138	157	200	...	...	281
Brunstead	28	60	82	86	96	130	138	157	160	195	199	206	270
Hevingham	...	...	80	...	...	...	138	...	...	...	...	...	...
Clenchwarton	22	61	...	80	106	131	132	131	...	...	...	...	275
Peterborough	47	...	58	66	92	136	114	143	163	...	...	...	263
F													
Palé	46	59	88	84	128	147	147	150	157	197	200	211	289
Betley	...	...	...	86	100	145	138	161	165	187	195	196	276
Lake Side	32	71	83	98	...	144	146	156	163	198	207	185	278
Ambleside	31	62	...	86	129	...	140	158	160	...	194	...	268
Scaleby	46	...	...	...	...	..	...	...	...	...	...	...	...
Cronkbourne	43	44	114	...	125	136	146	169	...	...	191	211	296
Orry's Dale	...	*91*	...	...	...	...	...	...	...	...	...	...	...
G													
Ardgillan	40	41	83	84	...	130	140	146*	171	*222*	...	222	294
Edgeworthstown	...	...	...	95	...	...	...	...	...	...	...	...	...

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1903—*continued.*

Station.	Hazel.	Colsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Westport	41	...	49	112	...	111	140	...	...	...	...	...	276
Chanter Hill	...	...	...	...	...	139	143	155	161	175	...	197	289
Loughbrickland	43	...	91	118	...	148	147	162	161	205	...	215	298
Saintfield	31	37	...	...	...	141	145	...	...	...	...	...	283
Antrim	70	72	84	...	...	145	142	157	...	208	...	206	298
Altnafoyle	41	71	90	121	...	143	145	...	175	212	...	...	...
Ramelton	72	...	72	95	...	143	142	...	167	...	...	...	...
H													
Kirkmaiden	...	37	...	119	...	150	149	...	180	...	209	202	...
New Galloway	32	83	101	117	...	157	151	169	165		203	...	...
Jardington	53	80	76	109	...	149	146	...	166	214	...	...	...
Moniaive	50	...	90	126	...	...	149	158	169	214	193	220	...
Port Ellen	...	...	107	107	...	157	131	...	168		...	...	...
Duror	60	62	87	120	..	...	140	159	163	192	189	...	285
I													
Doddington	42	54	74	86	101	118	124	159	167	...	...	...	...
Thirsk	39	34	72	82	100	144	138	158	161	182	188	194	280
East Layton	...	...	...	105	...	146	147	...	...	...	...	...	...
Durham	48	48	80	102	...	154	142	176	181	...	194	...	...
Corbridge-on-Tyne	62	74	93	96	...	...	142	165	172	213	...	...	...
Blyth	52	45	...	110	...	148	140	163	171	...	...	...	...
Lilliesleaf	...	...	92	113	...	154	156	...	...	...	...	...	...
J													
Kirriemuir	..	68	...	121	...	...	152	146	167	201	191	...	...
Durris	45	78	95	133	141	148	154	159	161	207	180	220	291
Aberdeen	...	75	121	...	...	155	159	176	184	...	...	...	...
Fordyce	43	...	...	...	...	152	153	162	168	190	199	...	289
K													
Invermoidart	39	...	108	...	...	...	150	175	180	218	...	...	289
Roshven	43	...	91	...	...	115	*115*	173	173	209	...	201	299
Beauly	54	73	119	...	...	158	159	171	174	195	201	...	314
Dingwall	53	85	90	109	...	148	151	162	165	...	201	...	...
Inverbroom	42	59	118	119	...	...	...	...	...	...	...	...	...
Watten	...	74	...	...	...	...	165	189	...	232	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

injured fruit blossom. *Botley* (C)—6th. Wryneck first heard. *Chiddingfold* (C)—The frosts of 13th-20th destroyed almost the whole of the blossom on pears and apples. *Coneyhurst* (C)—Queen wasps very plentiful. *Churt Vicarage* (C)—1st. Wryneck first heard. 19th. The more tender spring flowers, like *Dielytra spectabilis*, destroyed by the frosts of the last week, while the young gooseberries dropped from the bushes. *Churt* (C)—3rd. Wryneck first

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF 13 PLANTS IN 1903, AND THEIR VARIATIONS FROM THE 12 YEARS' AVERAGE, 1891-1902.

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1903.	Average for 12 Years.	Variation from Average.	1903.	Average for 12 Years.	Variation from Average.	1903.	Average for 12 Years.	Variation from Average.	1903.	Average for 12 Years.	Variation from Average.
Hazel	40	39	+ 1	34	*29*	+ 5	29	36	− 7	36	43	− 7
Coltsfoot	50	56	− 6	56	*50*	+ 6	58	62	− 4	51	65	− 14
Wood Anemone	78	86	− 8	75	*76*	− 1	71	85	− 14	76	89	− 13
Blackthorn	80	92	− 12	78	*86*	− 8	85	98	− 13	85	100	− 15
Garlic Hedge-Mustard	102	107	− 5	111	*101*	+ 10	98	112	− 14	101	115	− 14
Horse-Chestnut	121	120	+ 1	125	*120*	+ 5	131	126	+ 5	142	130	+ 12
Hawthorn	129	130	− 1	130	*128*	+ 2	130	132	− 2	127	134	− 7
White Ox-Eye	148	145	+ 3	150	*140*	+ 10	138	142	− 4	151	148	+ 3
Dog Rose	157	155	+ 2	155	*156*	− 1	158	157	+ 1	162	160	+ 2
Black Knapweed	175	174	+ 1	186	*173*	+ 13	177	171	+ 6	188	177	+ 11
Harebell	203	191	+ 12	187	*186*	+ 1	194	182	+ 12	194	190	+ 4
Greater Bindweed	190	184	+ 6	201	*186*	+ 15	196	187	+ 9	197	191	+ 6
Ivy	265	264	+ 1	265	*267*	− 2	272	270	+ 2	278	270	+ 8
Mean for the 13 Plants	134	134	Av.	135	*131*	+ 4	134	135	− 1	138	139	− 1

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	32	37	− 5	40	45	− 5	48	52	− 4	49	*50*	− 1
Coltsfoot	57	61	− 4	59	65	− 6	55	72	− 17	66	*72*	− 6
Wood Anemone	73	88	− 15	95	93	+ 2	78	87	− 9	92	*96*	− 4
Blackthorn	79	99	− 20	89	106	− 17	104	100	+ 4	116	*107*	+ 9
Garlic Hedge-Mustard	97	112	− 15	121	125	− 4	...	*119*	...	...	*122*	...
Horse-Chestnut	127	125	+ 2	143	129	+ 14	138	130	+ 8	153	*137*	+ 16
Hawthorn	125	131	− 6	143	137	+ 6	143	138	+ 5	144	*141*	+ 3
White Ox-Eye	144	146	− 2	159	152	+ 7	155	155	Av.	162	*155*	+ 7
Dog Rose	155	157	− 2	161	161	Av.	167	165	+ 2	169	*167*	+ 2
Black Knapweed	183	178	+ 5	194	187	+ 7	200	200	Av.	207	*184*	+ 23
Harebell	194	187	+ 7	197	185	+ 12	...	*194*	...	199	*197*	+ 2
Greater Bindweed	203	190	+ 13	201	191	+ 10	210	*195*	+ 15	211	*198*	+ 13
Ivy	269	264	+ 5	281	282	− 1	290	*274*	+ 16	285	*277*	+ 8
Mean for the 13 Plants	134	137	− 3	145	143	+ 2	144*	143*	+ 1*	154†	*148*†	+ 6†

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	49	*52*	− 3	44	*55*	− 11	46	*53*	− 7	40	45	− 5
Coltsfoot	51	*74*	− 23	74	*77*	− 3	73	*75*	− 2	59	66	− 7
Wood Anemone	82	*98*	− 16	108	*101*	+ 7	105	*99*	+ 6	85	91	− 6
Blackthorn	99	*109*	− 10	127	*112*	+ 15	114	*110*	+ 4	96	102	− 6
Garlic Hedge-Mustard	101	*124*	− 23	141	*127*	+ 14	...	*125*	...	109	115	− 6
Horse-Chestnut	144	*139*	+ 5	152	*142*	+ 10	140	*140*	Av.	138	131	+ 7
Hawthorn	141	*143*	− 2	155	*146*	+ 9	156	*144*	+ 12	138	137	+ 1
White Ox-Eye	164	*157*	+ 7	161	*160*	+ 1	174	*158*	+ 16	155	151	+ 4
Dog Rose	170	*169*	+ 1	170	*172*	− 2	173	*170*	+ 3	163	163	Av.
Black Knapweed	198	*186*	+ 12	199	*189*	+ 10	214	*187*	+ 27	193	182	+ 11
Harebell	191	*199*	− 8	190	*202*	− 12	201	*200*	+ 1	195	192	+ 3
Greater Bindweed	194	*200*	− 6	220	*203*	+ 17	201	*201*	Av.	202	193	+ 9
Ivy	280	*279*	+ 1	290	*282*	+ 8	301	*280*	+ 21	280	274	+ 6
Mean for the 13 Plants	143	*148*	− 5	156	*151*	+ 5	158†	*151*†	+ 7†	143	142	+ 1

* For 11 Plants. † For 12 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, earlier ,, ,,
Av. ,, average date (1891-1902).
The dates in *italics* are approximate averages.

heard. *Bagshot* (C)—Frosts set in after the 8th which did much damage to fruit blossom. *Weston Green* (C)—Pear, plum and apple blossom almost entirely destroyed by frost. *Slough* (C)—24th. Azaleas and lilacs ruined, cherry, apples, and pears damaged by constant frosts, keen winds, and prolonged dryness. *Beckford* (D)—Frosts destroyed all the blossom on plums, damsons, and pears, bush fruits about half a crop. But little flower on hawthorn. *Watford* (*The Platts*) (D)—5th. Cherry blossom abundant. *St. Albans* (D)—12th. Wryneck first heard. *Farnborough* (D)—The magnificent blossom on cherries, pears, and plums destroyed by frost. No blossom on apple trees. *Thurcaston* (D)—Great damage done to plums and gooseberries by frost. *Beeston* (D)—20th. Frosts every night, destructive to pear and plum blossom. *Hodsock* (D)—19th. Hawthorn and horse-chestnut foliage much browned, fruit blossom injured. *Macclesfield* (D)—Frosts in middle of the month destroyed fruit blossom and buds of horse-chestnuts. *Horbury* (D)—After 11th wind North and North-east with frosts at night which damaged plum and pear blossom. *Hatfield* (E)—A severe frost in the middle of the month blackened the elder, hawthorn, and the common nettle. *Lexden* (E)—North winds and frosts did much damage to fruit blossom. *Market Weston* (E)—18th. Horse-chestnut leaves blackened by "cold snap." The promise of fruit ruined. 20th. Asparagus cut by frost. *Tacolneston* (E)—18th. Blossom on pears and plums browned by frost; garlic, hedge mustard, and other wild plants much injured. *Brunstead* (E)—16th. Cut first asparagus. North side of trees and hedges browned by cold winds. *Lake Side* (F)—In most gardens no blossom on any of the apple trees. Plum and pear blossom destroyed by frost and gales. *Edgeworthstown* (G)—5th. Sand-martin first seen. 19th. Willow-wren first heard. *Saintfield* (G)—18th. Hard frosts at night. Apple blossom and early potatoes nipped and withered. *Antrim* (G)—23rd. This was the coldest night, the new fronds of hart's tongue fern were completely destroyed. The gooseberry crop a complete failure. *Ramelton* (G)—5th. Willow-wren first heard. The frosts, hail, and snow did much injury to the fruit buds. *New Galloway* (H)—17th. Wheatear first seen. *Doddington* (I)—Most of the flower buds on the horse-chestnut were destroyed by the mid-April frost. *Thirsk* (I)—17th. Frosts and keen North winds shrivelled up rhubarb leaves and did great damage to fruit blossom. *Durris* (J)—25th. Sand-martin first seen.

MAY.—*Altarnon* (A)—Butterflies very scarce till 18th. *Botley* (C)—Never saw primroses so fine or last so long. Carrots and peas have had to be sown two or three times owing to slugs. *Churt Vicarage* (C)—Very little prospect of fruit on either apples, pears, or bush fruits, owing to damage done to the blossom by frost. 26th. May-fly first seen. *Bagshot* (C)—Queen wasps numerous. 4th. Bloom buds falling off horse-chestnut owing to the frost. First strawberry blossoms blackened by frost. *Berkhamsted* (D)—18th. Butterflies abundant. *Leominster* (D)—There were two distinct periods of flowering of the hazels, horse-chestnuts, currants, apricots, peaches, etc., owing to the frost. *Northampton* (D)—Horse-chestnuts in some cases were almost blackened by the April frosts and cold winds, and scarcely opened a single flower on each spike. *Thurcaston* (D)—Horse-chestnut in coloured bud on April 22, but destroyed by frost. Did not flower till May 23. *Bocking* (E)—The cuckoo was hardly heard at all during the first three weeks in May, which is very unusual. *Market Weston* (E)—18th. Very little hawthorn or apple blossom. *Brunstead* (E)—23rd. Very few queen wasps this year. *Betley* (F)—31st. Scarcely any blossom on the apple trees. The April frosts did much damage to the blossom of pears and plums. *Westport* (G)—1st. Sand-martin first seen. *Saintfield* (G)—Slugs numerous and very destructive to peas, etc. *Altnafoyle* (G)—1st. Willow-wren first heard. *Jardington* (H)—Grass grew rapidly, and at end of month was

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1903.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Mawnan	4	...	...	...	...	...	...	67	95	145	180
Liskeard	2	113	117	...	...	...	44	...	95	132	...
Altarnon	4	100	113	...	139	282	42	106	108	138	145
Brixham	30	117	124	...	...	266	73	...	122	128	190
Paignton	...	114	115	...	...	249	67	127	109	...	...
Westward Ho	2	125	122	...	...	...	54	150	102	139	...
Sidcot	...	95	111	124	...	288	51	...	...	...	...
Clifton	...	*140*	...	...	...	...	...	...	98	130	...
Penarth	...	...	...	...	...	...	67	144	98	128	196
Bridgend	7	111	*131*	...	...	289	44	146	...	144	...
Castleton	27	95	113	...	139	295	29	81	115	113	146
Little Mill	28	103	113	131	130	282	48	118	97	105	132
St. Arvans	4	97	119	...	...	289	40	49	...	150	...
St. Davids	33	113	100	...	...	...	62	...	98	132	...
Aberystwith	11	100	122	...	143	263	49	110	104	139	178
B											
Skibbereen	3	99	115	...	...	...	33	137	99	101	...
Killarney	7	114	...	...	...	266	40	114	104	121	...
Ferns	2	105	115	...	...	274	45	73	120	120	120
Bagnalstown	...	101	...	...	158	...	...	115	...	...	...
Ovoca	29	98	120	...	*186*	279	39	88	100	141	144
Geashill	...	102	116	...	...	...	40	144	120	143	183
C											
Bembridge	1	97	106	104	...	316	37	...	110	122	173
Buckhorn Weston	2	114	108	125	143	312	55	...	113	128	173
Havant	2	93	110	107	...	312	10	67	91	143	...
Botley	4	113	110	119	130	312	44	85	98	139	146
Fordingbridge	5	108	...	111	152	...	37	55	118	144	...
Birdham	5	87	110	111	...	317	22	83	95	143	181
Muntham	4	101	115	118	*183*	305	*136*	146	*136*	145	...
Dover	...	118	...	...	...	318	...	...	...	...	...
Staplehurst	...	106	100	114	...	...	72	73	81	135	...
Maidstone	...	119	110	118	...	280	...	...	94	152	...
Chiddingfold	2	119	110	110	130	289	10	142	104	142	151
Cranleigh	1	114	111	109	...	...	77	...	110	110	...
Coneyhurst	34	110	101	118	138	...	41	108	...	...	..
Churt Vicarage	10	97	115	118	144	293	42	59	122	139	180
Churt	6	104	106	103	145	302	6	138	124	130	161
Oxshott	26	120	116	120	...	...	...	...	...	...	...
Bagshot	7	105	106	122	143	275	42	124	124	124	175
Weston Green	2	103	118	119	163	294	41	110	102	...	...
Marlborough	32	99	119	123	129	...	...	...	108	128	172
D											
Oxford	31	...	114	...	...	...	...	...	...	...	...
Beckford	28	111	111	119	136	289	41	132	110	151	...
Harefield	...	116	117	118	...	290	...	...	...	...	...
Chesham	...	109	118	124	...	300	...	115	115	138	...
Watford (The Platts)	2	117	118	117	...	249	...	147	...	...	...
Watford (Weetwood)	...	117	116	..	...	285	42	116	102	...	...

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1903—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
St. Albans (Worley Road)	...	107	110	...	...	...	...	...	...	...	...
Berkhamsted	7	110	110	119	...	283	42	102	100	145	173
Harpenden	...	117	116	118	...	...	...	80	89	148	...
Ross	2	97	113	120	152	285	2	...	111	...	...
Leominster	10	105	100	120	148	...	36	...	117	...	...
Farnborough	6	89	117	118	140	298	40	53	109	141	180
Thurcaston	...	...	...	...	...	...	...	...	142	143	...
Beeston	9	118	119	...	140	275	40	120	143	150	...
Hodsock	27	111	121	120	136	294	24	119	144	146	...
Macclesfield	29	*140*	*143*	...	...	277	51	100	146	...	...
Belton	1	...	...	...	...	...	21	...	...	...	...
Sheffield (Endcliffe Rise Rd.)	5	...	...	...	...	...	...	152	...	...	...
Sheffield (Ashgate Road)	24	...	122	...	136	291	...	...	...	...	...
Altofts	...	115	...	...	...	276	...	31	141	152	192
Ripley	1	83	98	...	144	304	34	97	145	152	...
E											
Broxbourne	4	106	118	...	153	302	39	51	125	...	..
Hatfield	6	117	111	112	143	...	...	...	...	...	...
Sawbridgeworth	2	100	115	120	125	303	40	...	...	141	...
Hitchin	6	120	120	115	...	...	...	...	...	...	...
Odsey (Ashwell)	...	115	119	127	130	295	...	...	...	...	...
Bocking	...	...	116	122	...	...	...	142	...	...	...
Lexden	1	112	118	118	133	296	40	51	129	129	176
Sproughton	...	111	118	118	129	...	40	42	124	141	...
Market Weston	8	120	99	120	135	296	36	136	131	141	178
Carleton-Forehoe	9	101	117	...	138	301	10	...	125	139	144
Tacolneston	...	120	120	...	...	...	27	...	...	141	...
Brundall	...	119	115	118	...	...	...	...	...	...	...
Brunstead	6	119	118	...	142	290	47	124	118	143	163
Clenchwarton	7	120	121	...	...	297	35	39	91	131	...
Peterborough	1	100	128	128	...	...	64	70	115	...	...
F											
Palé	35	105	112	...	138	274	43	110	135	145	188
Betley	40	116	116	...	130	273	68	140	93	130	...
Lake Side	25	125	123	...	144	...	43	143	*150*	152	198
Ambleside	38	115	121	...	131	...	40	98	...	...	190
Scaleby	46	...	...	...	...	...	...	...	...	...	...
Cronkbourne	27	*135*	122	...	...	285	24	120	125	136	...
Orry's Dale	24	...	...	...	...	...	...	...	...	...	...
G											
Ardgillan	26	125	125	...	...	267	...	47	90	...	168
Edgeworthstown	...	115	115	...	...	...	18	...	...	...	...
Westport	26	110	121	...	...	280	...	...	...	...	...
Chanter Hill	...	99	120	...	...	*254*	...	...	131	140	170
Loughbrickland	40	110	123	...	...	274	...	...	...	139	...
Saintfield	31	107	140	...	153	...	...	...	139	137	...
Antrim	6	98	139	...	145	274	62	40	139	155	...
Altnafoyle	39	122	140	...	...	...	...	...	141	...	195
Ramelton	28	111	111	...	140	267	31	147	...	144	...

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1903—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
H											
Kirkmaiden	21	100	135	...	...	...	72	...	124	...	...
New Galloway	27	118	121	...	...	259	42	125	148	...	...
Jardington	34	115	119	...	136	269	...	98	142	...	190
Moniaive	33	115	134	...	...	262	...	147	143	...	...
Port Ellen	...	116	119	...	...	...	20	...	...	...	...
Duror	39	116	117	...	140	281	46	140	151	...	...
I											
Thirsk	1	116	123	...	130	273	38	50	144	*182*	...
East Layton	27	117	127	...	146	...	24	102	...	142	...
Durham	34	120	*144*	...	128	269	*100*	142	144	148	...
Corbridge-on-Tyne	29	120	127	...	...	...	...	101	...	...	...
Blyth	41	115	...	...	...	...	55	...	...	...	...
Lilliesleaf	...	...	130	...	...	...	*105*	140	...	...	...
J											
Kirriemuir	...	121	...	...	...	288	42	...	...	...	...
Durris	36	128	122	...	*171*	283	46	129	143	*178*	*219*
Aberdeen	20	126	132	...	...	247	...	149	157	...	...
Fordyce	...	...	...	...	...	271	...	...	...	...	165
K											
Invermoidart	40	...	126	...	...	...	...	117	...	...	...
Roshven	...	116	96	...	...	...	...	146	144	...	...
Beauly	39	142	136	...	160	254	69	148	143	...	...
Dingwall	35	139	144	...	153	...	39	141	135	...	...
Inverbroom	46	...	134	...	...	...	49	...	...	...	...
Watten	...	...	...	...	...	...	79	...	144	...	*229*
Mean Dates for the British Isles in 1903	18 Jan. 18th	111 Apl. 21st	118 Apl. 28th	118 Apl. 28th	140 May 20th	284 Oct. 11th	42 Feb. 11th	107 Apl. 17th	119 Apl. 29th	137 May 17th	170 June 19th
Mean Dates for 1891-1902	Jan. 26th	Apl. 17th	Apl. 22nd	Apl. 21st	May 14th	Oct. 12th	Feb. 24th	Apl. 11th	Apl. 17th	May 9th	June 10th

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

very plentiful. 28th. Queen wasps very numerous. *Thirsk* (I)—27th. Very little blossom on hawthorn.

June.—*Bridgend* (A)—19th. Hay first cut. *Killarney* (B)—4th. The apples flowered well, but set very little fruit. 21st. Many fields of potatoes blackened by frost. *Bembridge* (C)—16th and 21st. Hoar frost. *Botley* (C)—All insects scarce. No oak-feeding caterpillars. *Churt Vicarage* (C)—29th

Butterflies very scarce. *Churt* (C)—Honey-bees suffered severely—many swarms died owing to cold and wet weather. *Bagshot* (C)—22nd. Haymaking began. *Harpenden* (D)—A great scarcity of apple blossom, and but little fruit. 21st. First wheat ear out of sheath ; later than in either of the previous 11 years. *Macclesfield* (D)—21st. Potatoes and dahlias killed. *Odsey* (E)—An unusual number of hares. *Market Weston* (E)—12th. Potatoes and bracken cut down by frost. *Carleton-Forehoe* (E)—14th. Potatoes and runner beans much injured by frost. *Tacolneston* (E)—12th. The tops of potatoes and French beans injured by frost. *Palé* (F)—21st. French beans blackened by frost. *Thirsk* (I)—28th. Haymaking not yet general. *Durris* (J)—Exceptional amount of blossom on the furze and broom. *Fordyce* (J)—The bloom upon the furze and broom more abundant than for many years. Wasps very numerous, but few slugs or snails. *Beauly* (K)—20th. Potatoes and bracken blackened by frost. *Dingwall* (K)—7th. Potatoes injured by frost. 19th. Potatoes more severely injured by frost. *Watten* (K)—Hawthorn blossom has been very scanty this season.

JULY.—*St. Arvans* (A)—1st. Strawberries fairly plentiful ; all other fruits scarce, especially wall fruit. 21st. First honey taken. *Botley* (C)—13th. Rose petals brown and shrivelled as if by frost. *Churt Vicarage* (C)—24th. Very poor crops of fruit. *Bagshot* (C)—Hardly any tree or bush fruit, and no peaches. *Oxford* (D)—2nd. Pear and plum trees blossomed again, and some of the latter in September bore a large crop of small plums. *Harefield* (D)—29th. Young grass to be seen growing through that which lies sodden in the fields. The hay saved earlier a good and abundant crop. *Hodsock* (D)—Very poor crops of early strawberries and blackcurrants. *Betley* (F)—31st. Vegetables in kitchen garden very fine this year. *Crankbourne* (F)—26th. Harvest began. *New Galloway* (H)—27th. Swift last seen. *Fordyce* (J)—Raspberries and currants a failure this year.

AUGUST.—*Mawnan* (A)—7th. Harvest began. *Altarnon* (A)—Wasps scarce. 17th. First wheat cut. *Ovoca* (B)—Very few butterflies, except large and small white ones. *Botley* (C)—Hardly any wasps. *Cranleigh* (C)—21st. Swift last seen. *Churt* (C)—The heather and ling never more beautiful. All kinds of butterflies scarce. 25th. Beans cut by frost. *Bagshot* (C)—1st. Scarcely a wasp to be seen. 5th. Corn harvest began. 25th. Hay carted to the yards for litter. *Oxford* (D)—1st. Have seen no wasps as yet. *Harpenden* (D)—Harvest not general till the third week in the month. *Hodsock* (D)—But few wasps. *Bocking* (E)—15th. Harvest began. *Lexden* (E)—The rain has soaked into the ground, and done much good to the forest trees. Bad season for harvesting farm seeds. *Clenchwarton* (E)—A bad season for honey. 12th. Harvest began. 29th. Potato disease prevalent. *Betley* (F)—31st. Only about a bushel of apples off 50 trees. *Lake Side* (F)—No nuts or wild apples, and no bilberries. 29th. Hay not all cut yet, and much lying about in the fields spoiling owing to rain. *Ambleside* (F)—There have been scarcely any butterflies. *Orry's Dale* (F)—No wasps seen here this summer. *Antrim* (G)—Wasps fairly numerous, but few house-flies. 18th. Swift last seen—the latest date I ever remember. *Moniaive* (H)—Corn harvest began on the 31st, but was not finished until after the beginning of December. *Thirsk* (I)—Very few earwigs and scarcely any wasps. Many large fruit-growers have not a stone of fruit in their orchards. 5th. The continued rain has quite spoilt the hay crop. *Corbridge-on-Tyne* (I)—31st. Very few wasps although an unusual number of queen wasps in the spring. *Fordyce* (J)—19th. Swift last seen.

SEPTEMBER.—*Mawnan* (A)—10th. Storms from West and North-west ; the foliage of every green tree where exposed turned brown. *Brixham* (A)—23rd. The swallows have not congregated as usual before taking flight, their disappearance was gradual. *Tiverton* (A)—10th. Many large trees blown down.

TABLE VI.—Estimated Yield of Farm Crops in 1903.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
Wheat	Av.	2 % O. Av.	4 % U. Av.	2 % U. Av.	8 % U. Av.	1 % U. Av.	6 % U. Av.	3 % U. Av.	36 % U. Av.	3 % U. Av.	1 % U. Av.
Barley	1 % O. Av.	1 % U. Av.	4 % U. Av.	1 % U. Av.	12 % U. Av.	7 % U. Av.	10 % U. Av.	4 % U. Av.	19 % U. Av.	7 % U. Av.	3 % U. Av.
Oats	3 % O. Av.	9 % O. Av.	Av.	7 % O. Av.	9 % U. Av.	Av.	6 % U. Av.	1 % O. Av.	15 % U. Av.	1 % U. Av.	1 % O. Av.
Corn Harvest began, average Date	228 (Aug. 16)	222 (Aug. 10)	230 (Aug. 18)	226 (Aug. 14)	239 (Aug. 27)	235 (ug. 23)	248 (Sept. 5)	249 (Sept. 6)	259 (Sept. 16)	236 (Aug. 24)	237 (Aug. 25)
Beans	1 % O. Av.	8 % O. Av.	16 % O. Av.	11 % O. Av.	4 % O. Av.	2 % U. Av.	5 % U. Av.	8 % U. Av.	18 % U. Av.	9 % O. Av.	13 % O. Av.
Peas	4 % O. Av.	2 % O. Av.	4 % O. Av.	2 % O. Av.	4 % U. Av.	7 % U. Av.	8 % U. Av.	2 % O. Av.	44 % U. Av.	17 % O. Av.	3 % O. Av.
Potatoes	24 % U. Av.	26 % U. Av.	23 % U. Av.	42 % U. Av.	24 % U. Av.	12 % U. Av.	1 % O. Av.	Av.	15 % U. Av.	2 % U. Av.	7 % U. Av.
Turnips	4 % U. Av.	5 % O. Av.	10 % O. Av.	9 % U. Av.	5 % U. Av.	Av.	17 % U. Av.	12 % U. Av.	36 % U. Av.	22 % U. Av.	6 % U. Av.
Mangolds	2 % O. Av.	Av.	3 % O. Av.	3 % U. Av.	9 % U. Av.	20 % U. Av.	12 % U. Av.	17 % U. Av.	63 % U. Av.	22 % U. Av.	2 % U. Av.
Hay (Permanent Pastures)	9 % O. Av.	27 % O. Av.	13 % O. Av.	15 % O. Av.	4 % U. Av.	9 % O. Av.	6 % U. Av.	5 % U. Av.	14 % U. Av.	3 % O. Av.	9 % O. Av.
Hay (Clover, etc.)	5 % O. Av.	28 % O. Av.	15 % O. Av.	13 % O. Av.	4 % U. Av.	2 % O. Av.	13 % U. Av.	7 % U. Av.	26 % U. Av.	Av.	5 % O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average.

The variations from the average in the above-mentioned crops have been obtained from the *Agricultural Returns*, 1903 (*Produce of Crops*), issued by the Board of Agriculture, while the average dates of the Harvest have been derived from returns which appeared in the *Agricultural Gazette*, August 10 and 17, 1903.

TABLE VII.—Estimated Yield of Fruit Crops in 1903.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H, J, and K W. E. and N.	B and G S. and N.	
Apples	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.
Pears	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.
Plums	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.	Much U. Av.
Raspberries	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	U. Av.
Currants	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	U. Av.
Gooseberries	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	U. Av.
Strawberries	Av.	O. Av.	Av.	O. Av.	U. Av.	Av.	Av.	O. Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, August 1, 1903.

TABLE VIII.—Variations from the Average in Mean Temperature, Rainfall, and Sunshine, 1902-3.

Winter 1902-3.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	+1·0	+0·8	+1·0	+1·4	+1·4	+0·6	+1·4	+1·2	+2·0	+0·6	+1·0
January	+1·2	+0·2	+2·0	+1·0	+2·5	+0·5	−0·2	−0·7	+1·0	−0·5	−0·5
February	+3·5	+3·2	+4·5	+5·2	+5·0	+4·5	+3·7	+4·5	+5·2	+4·0	+3·2
Winter	+1·9	+1·4	+2·5	+2·5	+3·0	+1·9	+1·6	+1·7	+2·7	+1·4	+1·2

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	−0·5	−0·3	−0·5	−0·3	−0·4	−0·3	+0·1	+1·4	+0·3	+1·1	+1·5
January	+0·7	+1·4	−0·2	−0·2	−0·3	+0·5	+1·4	+1·7	+0·3	+1·5	+2·3
February	−0·7	+0·3	−0·4	−0·4	−1·0	+1·1	+1·3	+3·2	−0·6	+2·0	+4·5
Winter	−0·5	+1·4	−1·1	−0·9	−1·7	+1·3	+2·8	+6·3	0·0	+4·6	+8·3

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	− 8	−19	−10	− 5	− 7	+ 1	− 1	−12	− 9	−13	− 1
January	− 8	−10	− 1	+ 2	+ 3	+ 7	− 3	−18	− 5	−15	− 2
February	−23	−29	− 3	− 6	+ 2	− 9	−30	−24	−18	−26	−36
Winter	−39	−58	−14	− 9	− 2	− 1	−34	−54	−32	−54	−39

Spring 1903.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	+2·5	+1·2	+3·7	+3·2	+3·7	+2·7	0·0	+1·5	+3·0	+1·0	+1·2
April	−1·6	−1·6	−1·6	−2·0	−1·8	−2·2	−1·8	−2·4	−1·6	−2·2	−1·8
May	+0·7	+0·2	+0·7	0·0	+1·0	−0·2	+0·2	+0·2	−0·7	−0·5	−1·0
Spring	+0·5	−0·1	+0·9	+0·4	+1·0	+0·1	−0·5	−0·2	+0·2	−0·6	−0·5

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	+2·7	+3·5	+0·8	+1·8	+0·4	+1·9	+2·9	+4·2	+0·1	+1·7	+3·6
April	+0·9	−0·3	+1·2	+0·6	+0·5	+0·5	+0·4	−0·5	+0·2	−0·1	+0·9
May	+0·5	−0·3	+0·5	+1·0	+0·5	+0·2	+0·4	+0·5	+0·2	−0·4	+0·1
Spring	+4·1	+2·9	+2·5	+3·4	+1·4	+2·6	+3·7	+4·2	+0·5	+1·2	+4·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	−27	−18	− 1	−10	+ 4	−22	0	−21	−17	−10	−18
April	− 9	−24	− 6	+ 3	−12	+21	−34	+ 2	+12	−11	−13
May	− 8	−17	+ 2	−32	−20	−19	−27	−29	−36	−26	−22
Spring	−44	−59	− 5	−39	−28	−20	−61	−48	−41	−47	−53

+ indicates above the average, − below it.

TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1903.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June . .	−2·0	−1·0	−2·0	−2·2	−3·0	−1·7	−1·2	−0·7	−2·5	−1·5	−1·7
July . .	−0·6	+0·2	+0·2	0·0	0·0	−0·8	−0·4	−0·8	−0·6	−1·2	−1·6
August . .	−2·0	−2·0	−1·7	−2·5	−1·2	−2·0	−1·7	−1·5	−1·5	−1·7	−2·0
Summer . .	−1·5	−0·9	−1·2	−1·6	−1·4	−1·5	−1·1	−1·0	−1·5	−1·5	−1·8

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June . .	+0·8	+0·6	+1·5	+0·2	+2·1	−0·4	−1·3	−1·0	+0·2	−0·5	−1·4
July . .	+0·2	+0·8	+0·9	−0·2	+1·3	+0·2	+0·7	+0·6	+1·4	+1·6	+1·9
August . .	+1·2	+1·2	+1·3	+1·8	+1·6	+1·0	+1·8	+1·9	+0·2	0·0	+2·8
Summer . .	+2·2	+2·6	+3·7	+1·8	+5·0	+0·8	+1·2	+1·5	+1·8	+1·1	+3·3

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June . .	−35	−20	−26	−25	−37	+20	−18	+11	−13	−23	+1
July . .	+18	−7	+10	−4	−25	+10	−4	−3	−17	−22	−4
August . .	−3	+13	−1	−7	−4	+27	+19	+36	+13	+32	+8
Summer . .	−20	−14	−17	−36	−66	+57	−3	+44	−17	−13	+5

AUTUMN 1903.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September .	+0·6	+0·8	+1·2	+0·4	+1·2	0·0	+0·8	+0·6	+0·2	+0·2	+1·0
October . .	+2·5	+0·7	+3·2	+2·0	+2·7	+1·5	+0·2	+1·2	+1·5	+0·2	0·0
November .	+1·5	+0·7	+1·2	+0·7	+1·2	+0·5	+1·2	+0·7	+0·7	+0·7	+0·7
Autumn . .	+1·5	+0·7	+1·9	+1·0	+1·7	+0·7	+0·7	+0·8	+0·8	+0·4	+0·6

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September .	+0·6	+0·7	−0·4	+0·5	+0·2	+1·6	+1·4	+1·9	+0·8	+0·6	+0·1
October . .	+4·2	+1·5	+3·2	+3·6	+1·8	+3·5	+2·7	+4·7	+3·6	+2·7	+2·7
November .	−1·1	−1·5	−1·0	−0·5	−0·4	+0·3	−0·5	−0·1	−0·8	−0·9	+0·8
Autumn . .	+3·7	+0·7	+1·8	+3·6	+1·6	+5·4	+3·6	+6·5	+3·6	+2·4	+3·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September .	−2	+6	+4	+10	+7	+28	+32	+23	+9	+12	+29
October . .	−19	−6	−20	−18	−24	−16	−4	−23	−23	−21	−22
November .	+13	+2	0	+6	−8	+18	−3	+8	+16	+5	−6
Autumn . .	−8	+2	−16	−2	−25	+30	+25	+8	+2	−4	+1

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

TABLE IX.—Supplementary Observations in 1903.

PLANTS.

Winter Aconite.

Station.	District.	Date.
St. Arvans	A	Jan. 6.
Ovoca	B	,, 28.
Bembridge	C	,, 8.
Bagshot	C	Feb. 9.
Watford (The Platts)	D	Jan. 7.
Watford (Weetwood)	D	,, 6.
Berkhamsted	D	,, 5.
Scaleby	F	,, 27.
Cronkbourne	F	,, 7.
New Galloway	H	,, 24.

Corncrake (first heard).

Station.	District.	Date.
Bridgend	A	May 7.
Ovoca	B	April 30.
Geashill	B	May 3.
Harefield	D	June 13.
Beeston	D	May 11.
Edgeworthstown	G	,, 4.
Westport	G	April 30.
Loughbrickland	G	May 1.
Antrim	G	April 30.
Ramelton	G	,, 10.
Jardington	H	May 8.
Corbridge-on-Tyne	I	,, 2.
Durris	J	,, 22.

BIRDS.

Chiff-Chaff (first heard).

Bridgend	A	March 8.
Ovoca	B	,, 26.
Botley	C	,, 25.
St. Albans	D	,, 22.
Ross	D	,, 31.
Ripley	D	,, 27.
Edgeworthstown	G	April 5.
Loughbrickland	G	,, 14.
Saintfield	G	,, 18.
Antrim	G	,, 12.
Altnafoyle	G	May 2.
Ramelton	G	April 1.

Swift (first seen).

Mawnan	A	May 10.
Brixham	A	,, 10.
Coneyhurst	C	April 24.
Churt Vicarage	C	May 14.
Harefield	D	,, 19.
Leominster	D	,, 4.
Westport	G	,, 19.
Antrim	G	,, 7.
Altnafoyle	G	,, 21.
New Galloway	H	,, 19.
Corbridge-on-Tyne	I	,, 22.
Durris	J	,, 23.

by the gale. The leaves on other trees turned brown and looked just as the foliage on a beech hedge looks in winter. The effect on the landscape was very strange, plenty of leaves on the trees, but all dead. *Sidcot* (A)—10th. A severe storm of wind and rain from West to North-west. Many elms of great size were torn up by the roots, and one or two snapped off. The leaves of trees, shrubs, and plants, were shrivelled up or turned black on the windward side—the effect of the salt spray blown inland. *St. Arvans* (A)—10th. Several large trees were blown down by the gale. *Ovoca* (B)—Very few mushrooms. *Geashill* (B)—Potatoes diseased. *Maidstone* (C)—10th. Much damage done to hops by storm. *Chiddingfold* (C)—10th. A gale from South-west and North-west blew down trees. *Churt Vicarage* (C)—10th. A violent gale, two rows of broccoli in the garden levelled to the ground, and some of the plants torn up by the roots. *Bagshot* (C)—No mushrooms. 10th. Fruit trees blown down. *Beeston* (D)—12th. Very few butterflies. 14th. Swallows congregating. *Hodsock* (D)—Much damage done in garden by high winds. *Sheffield* (*Endcliffe Rise Road*) (D)—16th. Young swallows were being fed by their parents in a barn. *Tacolneston* (E)—22nd. Painted lady butterflies unusually numerous. *Brunstead* (E)—22nd. Many painted lady butterflies. *Clenchwarton* (E)—24th. Harvest ended. *Palé* (F)—Owing to floods the river Dee carried away much of the mown hay. *Chanter Hill* (G)—After swallows left the weather became warm,

TABLE X.—Leafage and Defoliation of Lime Trees in the "Garden" of the Bank of England, London, E.C.

Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.	Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.
1888	April 20	October 26	1897	March 23	October 25
1889	March 30	,, 21	1898	April 5	,, 27
1890	,, 31	,, 28	1899	,, 4	,, 20
1891	,, 18	,, 29	1900	,, 6	,, 29
1892	,, 30	,, 24	1901	,, 9	,, 26
1893	,, 14	,, 20	1902	March 27	,, 20
1894	,, 27	,, 22	1903	,, 21	,, 23
1895	,, 23	,, 31			
1896	,, 24	,, 17	Means	March 29	October 24

result—an invasion of midges and gnats into the house during the evening and night. *Ramelton* (G)—Never remember so few wasps or flies as this year. *Jardington* (H)—Although queen wasps numerous in the spring, there were very few wasps to be seen in the autumn.

October.—*Altarnon* (A)—27th. Unprecedented flood. *Bembridge* (C)—10th. Red admiral butterflies numerous. *Churt Vicarage* (C)—22nd. Autumn tints very poor this year. 30th. Picked a wild ripe strawberry. *Bagshot* (C)—Not many acorns. Some oats still uncut. *Harefield* (D)—4th. Martin last seen. *Harpenden* (D)—Some corn standing in shocks in the fields in the middle of the month. Potato disease very prevalent, much of the crop still in the ground (January 1904) not being considered worth lifting. *Northampton* (D)—In some villages the number of apples is less than the number of apple trees. *Ripley* (D)—15th. One nest of swallows with four young ones in it. *Bocking* (E) Acorns and wild fruits quite average. *Brunstead* (E)—3rd. Walnut tree bare of leaves. *Palé* (F)—The corn crops were much spoilt, for the shocks were outstanding for over six weeks until they were green with sprouting grain. *Lake Side* (F)—13th. Saw two fields of oats to-day standing in sheaves with heads of corn sprouting owing to the rain. They were covered with green blades about 4 ins. long. *Saintfield* (G)—15th. About one-half of the oat crop gathered in, the other half yet in the fields in a bad state. *Thirsk* (I)—20th. Much corn still in the fields. *Kirriemuir* (J)—The worst harvest in an experience of 40 years. Instead of lasting a month it lasted 10 weeks.

November.—*Altarnon* (A)—18th. Corn harvest finished. *Sidcot* (A)—10th. Several pear trees in full blossom. 19th. Dahlias killed. *Killarney* (B)—For many weeks no hay could be carried, nor potatoes dug. 7th. An apple tree in second bloom. *Ovoca* (B)—18th. 26 different wild-flowers found in a short walk. *Buckhorn Weston* (C)—8th. Last load of barley carried. *Maidstone* (C)—3rd. Many summer wild-flowers still in blossom. *Churt Vicarage* (C)—The fruiting spurs on the apple trees of unusually weak growth. 16th. Dahlias killed by frost. *Bagshot* (C)—3rd. Autumn tints at their best. 20th. Dahlias killed. *Weston Green* (C)—Potatoes much diseased. *Beckford* (D)—Land sodden, but little wheat planted before the middle of the month. *Berkhamsted* (D)—19th. Dahlias killed by frost, or a fortnight later than the average date of their destruction in the previous 18 years. *Macclesfield* (D)—Ash trees in full leaf until after the 16th. *Bocking* (E)—6th. Harvest ended. *Lexden* (E)—30th. Here and there an oak still in full leaf. Many kinds of trees, by the widened cracks in their old bark, show that they have made unusual growth in stem circumference this year. *Brunstead* (E)—7th. Dahlias killed. *Clenchwarton* (E)—1st. Potatoes rotting in the ground. Very few partridges. 9th.

Gathered a dish of ripe greengages. *Palé* (F)—6th. Dahlias killed. *Betley* (F)—Found over 50 flowers in bloom in the garden during the first week of the month. *Cronkbourne* (F)—17th. Dahlias killed. *Orry's Dale* (F)—The great feature of the year has been the extraordinary number of rats, which eat seed peas, green peas, corn, potatoes, turnips, etc. *Jardington* (H)—Towards the end of the month much corn was still in the fields and growing green in the stook. *Fordyce* (J)—Barley the best crop of the season. Potatoes sound.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) said that the Report presented by Mr. Mawley was a most interesting one. Each year the facts were placed before the Society with such regularity and ease that the value of the work and the labour involved were apt to be under-estimated. We have hitherto procured all necessary food supplies with so much comparative ease that but small notice has been directed to the condition, etc., governing food production. It is evident that the time is rapidly coming when this question must be seriously dealt with. The appearance of various butterflies was a curious phenomenon. Last year the painted-lady butterfly was plentifully reported in Kent, and it was generally supposed that it had come over from the Continent a few years back. The cloudy-yellow butterfly was also very numerous for two successive years. Special thanks were due to Mr. Mawley for his labours, which are of very real importance.

Mr. F. C. BAYARD remarked that Mr. Mawley had steadily carried on the work from the point at which his predecessor, the Rev. T. A. Preston, had left off, and had now brought many things to a focus which Mr. Preston had only just begun. He (Mr. Bayard) felt indebted to Mr. Mawley for the labour the work entailed, and the results obtained. Mr. Mawley had shown in a very interesting manner the relationship existing between insects, plants, and crops. This relationship really indicated the character of the climate of the year. In the past year the butterflies were late in making their appearance, probably owing to the spring frosts, which also were the cause of the scarcity of fruit. The poorness of the vegetable and other crops might be put down to the excessive wet, and these facts clearly showed the climatic effect on the produce of the soil. He had brought with him that evening a photograph which was taken as late as November 18, of some blackberries in beautiful condition and quite ripe. He had never seen anything like it before at that time of year, and would like to ask Mr. Mawley if the date was a record one. It seemed to him (Mr. Bayard) that the dry and bright weather in November had brought on the fruit much as usual, although at so late a season. He would like to ask what effect the dry period at the end of June and the beginning of July had on the hay crop. Around London great quantities were gathered in then in excellent condition.

Mr. C. HARDING was glad Mr. Bayard had called attention to the amount of work involved in the preparation of the Report. Most papers were like a flash in the pan, but Mr. Mawley had to have his in mind from the beginning to the end of the year. To see the diagram for the 13 years was alone enough to show the labour entailed in its compilation. The lateness of the blackberry was alluded to by Mr. Bayard, and it was well known that last year there was no fruit when it should have been plentiful. November was particularly dry and fine, and perhaps the finest month of the year. Mr. Mawley had remarked that the wet was not altogether without its advantages. This would seem to be the case, for in 1902, which was also a wet year, the deaths in London were

7000 below the average, while last year the record figure of 15,000 deaths fewer than usual was registered. The summer months were particularly healthy.

Mr. A. BREWIN thought that the healthiness of the year was probably due to the constant flushing of the drains and the continued washing away of the accumulating filth by the repeated heavy rains. The health among the Stock Exchange clerks was noticeably better than usual, and the Medical Officer in his report says, "The wet weather, by restricting out-door pursuits, has materially lessened the number of accidents."

Mr. B. LATHAM thought that the healthiness of last year had nothing to do with the flushing of the drains. In places where there were no drains the general health was better than usual, and in London the heavy rains had often resulted in flooding of basements with sewage, which could not have had a beneficial effect on health. It was a well-known fact that a wet and cool summer is a healthy one. Mr. Latham thought Mr. Mawley's figures could not be discussed. They were facts, and everybody was glad to see them. Notwithstanding the low temperatures of April and the cool summer, the mean temperature for the year was above the average. Probably no previous year was so wet in the south of England as last year. It was a disastrous one in many places, and some fields were never reaped. He himself had seen some standing corn at Christmas time, but probably that was due to negligence on the part of some of the farmers, as the cases were isolated ones and the harvest had been gathered in in the same neighbourhood. This showed the necessity of improvement in the methods of the British agriculturist.

Mr. F. DRUCE remarked that he had the previous evening seen a newspaper heading which might serve Mr. Mawley for next year's report. It was a statement that the boating season had commenced! This of course referred to the heavy flooding in the Thames valley, and clearly showed the abnormal conditions that were now prevailing. A gardener in the south of England had last year told Mr. Druce that the summer had been the worst for 40 years past. There were no potatoes and no apples owing to frost, and strawberries were the only fruit that yielded a good crop.

Mr. W. B. TRIPP remarked on the great variation in the amount of water in the Tring reservoirs as shown by the photographs exhibited on the screen. In this country, unlike on the Continent and in America, there were great fluctuations in the water level, owing to our dependence on the rainfall for the supply, and that there were no large lakes or snow-clad mountains to keep up the level in the summer months. This, he thought, should make us more careful of the storage of the rain when it fell, so that the supply could be kept up in time of drought.

Mr. R. H. CURTIS wished to join in congratulating Mr. Mawley upon the completion of another of his interesting and valuable Phenological Reports. The destruction of trees by the gale of February 26-27, 1903, to which Mr. Mawley had referred, was an interesting arborical feature of the year. In the neighbourhood of Dublin it had been extremely great, and in the Phœnix Park alone 1242 forest trees—oaks and elms, but chiefly elms—had been blown down; many of them were of great size, and in their fall their roots had in some instances lifted boles of earth of immense size and weighing many tons. The famous Chesterfield avenue of elms had been entirely destroyed. When he saw it a few weeks after the gale only a few isolated trunks were left standing, and nearly all of those had been stripped of their branches. Of smaller trees, such as thorns, 1706 were destroyed in the Park. But all around Dublin in the suburbs the destruction of trees was very great. In Westmeath also, at Knockdrum Castle, 60,000 trees are said to have been blown down; and at Emo Park, Portarlington, 40,000. One fact worth

special notice in connection with the large rainfall of last year (1903) was its effect upon forest trees in England. This he had been assured had been altogether beneficial. He had recently been told by a gentleman who was able to speak on that subject with authority, that for a long time past such trees, and particularly oaks, had been getting into a very unsatisfactory state. They had shown a general lack of vigour, which on some estates had been so marked that it was feared many fine trees would perish altogether. But the rainfall of 1903 had worked wonders with them, and forest trees in England were now looking better, more healthy and vigorous, than they had done for many years past.

Mr. J. E. CLARK said we had now to consider the point as to the real value of such a rainfall to the country as a whole. The effect on the trees and the benefit to the water-supply were of great importance, but he questioned whether the damage caused by the floods did not more than compensate for the other advantages. At the present moment the lower pasture-land was un-get-at-able in many parts owing to the floods, and the upper pastures were becoming exhausted. He had recently looked down on as much as 50 miles of land under water in Mid Somerset. There was a great contrast last year in the state of vegetation between the early and latter part of spring; and the promise of an exceedingly early season, by the oak tree being in leaf at Croydon on April 5, was not fulfilled, owing to the sharp frosts a little later in the month. At the end of September and the beginning of October haymaking was in progress at Marden Park on the North Downs above Croydon, and it was remarked that the scent of the hay was particularly sweet-smelling. The abundant flowering of bushes in October, especially of the holythorn and laurustinus, was a very marked feature of last year, and was probably due to the copious rains and the mild autumn. As with other speakers, he had noticed the great quantities of ripe blackberries in November. In fact they were to be gathered in greater numbers than is usual in October, and appeared to be more plentiful than in any year since 1871 at so late a date. Even as late as Christmas he had found ripe fruit in Somerset in previous years, while at Croydon, this year, the blossom was seen, but no fruit. The present spring in Somerset was quite as forward as that of last year.

Mr. J. HOPKINSON remarked that Mr. Mawley's method of selecting a small number of species to be observed every year was a great advance for accuracy of deductions upon the old plan of observing a large number occasionally only, but nevertheless some old observations were of considerable interest, and he handed round a scarce edition of the Rev. Gilbert White's *Naturalist's Calendar*, being a large-paper copy (4to) of the first edition, by Aiken (1795). The earliest and latest dates of appearance, etc., of nearly all the species in Mr. Mawley's list, with many others, were given from observations extending over 25 years, from 1768 to 1792, the date of White's death; but of some, the plants especially, there were very few observations. If the extreme dates were any indication of the average it would appear that for a similar period up to the present time the average dates in Hertfordshire were considerably earlier than at Selborne more than a century ago. It would, he thought, be interesting to obtain Gilbert White's actual dates, in his Journal, to compare their averages with the averages of recent observations of the same species in the same neighbourhood, and to see if they gave any indication of a change in our climate.

Dr. H. R. MILL remarked that he would like to ask Mr. Mawley if any relation had been established between the rainfall and the various phenological phenomena. At present he was still unable to speak definitely as to the rainfall over the country as a whole; but it was apparent that in 1903 some parts were very wet, as, for instance, around London, whilst other parts differed but little from the average. In a strip of country from Leicester to Hull the excess was

only 10 per cent of the average, but about London it was as high as 50 per cent. Again, there was another dry band from Dungeness, through Romney Marsh to the mouth of the Thames, whilst on either side the difference from the average was very large. He would like to ask if there was any marked difference between the flowering and growth of plants in the comparatively dry districts and in the wetter areas. A noticeable feature of the summer rainfall had been the small number of rainy days in June in the London district, a remarkable fact considering the very heavy rainfall. He could not help feeling sorry for the state of the British farmer, whose conservative methods made him slow in adopting new processes applicable to exceptional years, when an average result could generally be obtained by keeping to the ancient ways. In some foreign countries, which were generally as wet as last year proved to be here, harvesting was greatly assisted by using screens or hurdles on which to hang the crop, so as to keep the hay or corn off the ground, and allow the wind to blow through and dry them between the showers. Such an arrangement might have been very useful last year in this country.

Mr. E. MAWLEY, in reply, said it was evident from some of the remarks that had been made that certain statements in the Report had been unnoticed. This was always likely to be the case owing to the number of facts that had to be dealt with, and the condensed form in which they were presented—for instance, Mr. Bayard's reference to the absence of any mention of the June and July drought, and the allusion made by Mr. Curtis to the benefit done to forest trees by the excessive wet after so many years of dry weather; both of which would be found to have been duly noted in the Report. The blackberries shown in Mr. Bayard's photograph were excellent specimens for so late in the year. He was pleased to receive Mr. Curtis's correction with regard to the character and number of the trees blown down in Phœnix Park, Dublin, during the February gale. With regard to the diagram illustrating the times of arrival of some of the spring migrants, he explained that, unlike the plant diagrams which gave the mean dates of flowering in each district for the year 1903 alone, those for the birds were intended to show the mean dates of arrival for the whole of the British Isles for each of the last 13 years. Unlike Mr. Clark, he had found the earliest plants had flowered rather later this year than in 1903. As regards the effect of the recent continuous rains upon the pastures, and more particularly upon the young wheat, it could not be otherwise than detrimental. The fact was, that little if any rain was required by any of the ordinary farm and garden crops during the winter months. When excessive, the rainfall, among other things, impoverished the soil, by washing out of it much of the soluble fertilising qualities it contained. He was very interested in Mr. Hopkinson's remarks on the phenological work done by the Rev. Gilbert White, and only regretted he had not the necessary leisure to institute the comparisons he had suggested, as considerable care would have to be exercised before the two sets of records could be rendered fairly comparable. He was much encouraged in the preparation of these Phenological Reports by the favourable way in which they were always received, and also by the consistent manner in which the variations from the average in the different districts continued to support each other in Table I.

Halo Phenomena in Russia.—Prof. Dr. E. Leyst has contributed a long paper (136 pp.) on this subject to the *Bulletin de la Société Impériale des Naturalistes de Moscou*. He has discussed the observations of halos and coronæ in Russia, and arranged them in eleven groups, viz.—North-east, North-west, Central, South-west, Black Sea, South-east, Caucasus, Caspian and Transcaspian,

West Siberian, East Siberian, and Siberian East Coast. The periodicity differs in the different groups. The author deals with the observations under five heads, viz.—1. Material (observations); 2. Annual Curve; 3. Daily Curve; 4. Geographical Distribution; and 5. Secular Change, and the connection with Sunspots.

In his summary the author calls attention to the constant confusion between Hof (Halo) and Ring (Corona) in the "Instructions" of more than one country.

Dr. Leyst points out that pillars close to the sun are a phenomenon common to Russia, but apparently unknown elsewhere. These pillars have their maximum of frequency in January, the coronæ in April. The minimum for pillars is August and September, and for coronæ in October. Pillars are principally seen in Siberia, and coronæ in the central group, east of St. Petersburg. Lunar coronæ are most frequent in winter, in proportion of 49 to 2 in summer.

It is not the case that halo phenomena are much more common in Arctic regions than elsewhere.

No connection between halo phenomena and sunspots is proved.

Climate of Guatemala.—Dr. Gustav Eisen contributes some interesting notes on a journey in Guatemala during the months of March to December 1902, in the *Bulletin* of the American Geographical Society for June 1903. Guatemala may be said to belong to the "Moist Tropical Zone." The climatic conditions depend not only on its situation but upon the height and extent of the mountains. The great feature which distinguishes Central America from Mexico is the rainfall, which, in the case of the former, is greater and more evenly distributed, owing to its originating from two distinct sources at the same time, the Pacific Ocean and the Caribbean Sea. The humidity of the air in Guatemala is great, but differs in different localities, being greater as a rule in the mountains and in the low coast belt than in the valleys in the interior. The mountain region in the north is much more humid than that in the south, and the humidity of the air is greater on the Atlantic coast than the Pacific. Three distinct zones of precipitation are noticeable, but the rainy season, as a rule, occurs between April and November, the other months being those in which the least rain falls.

Regarding temperature, there are two maxima and minima annually, the former occurring in April-May and August, and the latter in July and December-January. The mean temperature is 66° in the city of Guatemala. The temperature is comfortable and agreeable in both winter and summer except for the narrow coast belt. Thunderstorms are characteristic of all parts, and the phenomenon of circular lightning is often observed.

A New Arctic Expedition.—The St. Petersburg Physico-Chemical Society has projected a new Arctic expedition to be undertaken for the following objects: observations of solar radiation and atmospheric refraction, of cloud movements, and of atmospheric electricity in connection with the extinction of ultra-violet light; determination of the phenomena of terrestrial magnetism and of electric currents in the ocean; chemical analyses of the composition of the air and water; and examinations of the polar ice.—*Nature*, January 28, 1904.

OBSERVATIONS BY MEANS OF KITES AT CRINAN IN THE SUMMER OF 1903.

By W. H. DINES, B.A., F.R.Met.Soc.

[Read February 17, 1904.]

I HAVE to give an account of the work done on behalf of the joint committee of the British Association for the Advancement of Science and of this Society, and I must confess at the outset that the results obtained do not come up to the expectations formed concerning them beforehand. This is due to various accidents and misfortunes, and to the character of the weather. Some of these accidents might have been avoided, a remark which indeed is true of all accidents strictly so called; but, unfortunately, kite flying, even when a steam-vessel is employed, is still dependent on the weather, and if the weather in the south of England were bad last summer, it was certainly very much worse on the west coast of Scotland. The rain that fell during August at Crinan amounted to 8·62 ins., and there were only three fine days during the month. This alone would not have mattered, since it is just as easy, though not so pleasant, to fly a kite during rain as in fine weather; but the rain was often accompanied by thunderstorms and gales, and neither of these phenomena afford desirable conditions for the purpose.

By suitable precautions the risk from lightning to the observers may be almost entirely obviated, but the steel wire that holds the kite would not be likely to remain very long in a thunderstorm unfused, and the breaking of the wire means in general, when working over the sea, the loss of the kites and instruments.

As a rule, thunder is very rare on the west coast of Scotland during the summer, and so also are gales, the usual difficulty being a want rather than an excess of wind; but last year the observer at Malin Head, the nearest station that reports daily to the Meteorological Office, reported winds amounting to a gale on twenty occasions in August (eleven force 7, and nine force 8, on the Beaufort scale), and most of these occurred while the vessel was available. However, the weather is unalterable, and it is during exceptional weather that observations are especially valuable. Further improvements in the apparatus and methods may, I hope, ultimately make us almost independent of the weather.

It will serve no useful purpose to give in detail the other causes that led to so poor a result, save one relating to the kites, which I mention in hopes that it may save others from a similar trouble.

As the result of many experiments during the winter of 1902-3, various modifications were adopted, and a kite was finally obtained that seemed to meet all requirements. The improvements on those used in 1902 were that the new kite would fold up completely, and was thus more easy to store on the vessel; and, secondly and chiefly, that it gave a much more uniform pull, and thus in strong winds there was less risk of breaking the wire. Two of these kites were thoroughly tested during March and April at Oxshott; and as they seemed satisfactory, six more apparently exactly similar kites were made for use during the summer. But it was found at Crinan that these new kites would not fly

properly; they were perfectly steady, but gave a very poor angle, 45° instead of 60°, and a very small pull: 30 lbs. seemed the maximum, even in strong winds. It was finally discovered that the material of the sails was different; it had been supplied by the draper under the same name and at the same price, but was in reality a more porous cloth, although the difference was not noticeable to an uninitiated person. Varnishing the upper sails made the kites as good as the others, but a month had been wasted.

At the joint request of the Government Grant Committee of the Royal Society and of the Royal Meteorological Society, the Lords Commissioners of the Admiralty had very kindly offered the use of a vessel for July and August; but, unfortunately, the one selected for the purpose met with an accident and was sunk in Plymouth Harbour. In consequence of this the Government Grant Committee made a grant of £200 for the hire of a vessel. Great difficulty was experienced in finding one, and, finally, the tug *Renown* of Leith was chartered. She did not reach Crinan until August 13, and was not a very comfortable boat to work from during the bad weather that prevailed so frequently after that date.

The apparatus has been previously described (*Quarterly Journal of Royal Meteorological Society*, vol. xxix. No. 126). The only differences worthy of mention are the following:—Several kites of a larger size, viz. 9 ft. high instead of 7 ft. 6 ins., and one of 12 ft. high, were used. The 7 ft. 6 ins. kites contain 60 sq. ft. of lifting surface, the 9 ft. kite 86 sq. ft., and the 12 ft. kite 156 sq. ft., the corresponding weights being approximately 8 lbs., 10 lbs., and 20 lbs. The large kite was very unwieldy and could only be used on calm days. A special device was required for starting it from the vessel, and it needed two people, besides the one at the winding gear, to start it from the land; but once up it flew well, and carried the instruments to heights that would have been quite unattainable in similar weather with the smaller kites. The 9 ft. kites were very handy on the few occasions when the weather was moderate: they were not built to stand strong winds. One of them, unaided, took the instruments to a height of 7600 ft.

I take this opportunity of correcting a mistake I made in my address in January 1903. I then stated that the distribution of the kites on the line did not affect the maximum height, but it is not so. The best height is attained by accumulating the kites on the far end of the line, but it is more convenient to use one large kite instead of two small ones.[1]

[1] Taking moments about the winding gear it is obvious that the effective moment for lifting the instruments is greatest when the kites are all at the end of the line, the ratio being 3:4 for half the kites in the middle and half at the end, to all the kites at the end. For a uniform distribution of a large number of kites along the line, and the same number at the end, the ratio of the moments is almost 2:4. Hence, plainly, it is advantageous to concentrate the kites at the far end in so far as other considerations will permit. The great obstacle to getting a good height is the wind resistance on the wire. If we assume that the tangential force is zero, and that the normal force varies as the cosine of the inclination, and further make the assumption that when the kites are all at the end we may integrate as though the wire formed the arc of a circle, it is not difficult to calculate the height that should be reached. There is, however, one unknown constant, and that is the normal wind resistance on the wire for a specified velocity. I have worked out a good many cases, taking this as equal to the weight of the wire with a velocity of about 25 miles per hour, and the results agree well with the actual heights obtained at Crinan in 1902 under various conditions of pull and altitude. Taking this assumed value for the wind resistance into account, it appears that two kites at the end have an advantage of 6 to 7 per cent over one kite at the end and one in the middle.

It has been stated that the weight of a kite must, for the sake of strength, increase as the cube of its linear dimensions, whereas the lifting surface only increases as the square. This is not strictly true; but, unfortunately, the weight of a kite does increase in a larger ratio than the lifting surface, and it is doubtful whether, with the box type of kite, anything beyond 12 ft. would be of much practical use.

A different clamp for attaching the supplementary kites was used. This consists of a piece of steel wire of $\frac{1}{16}$ in. diameter, 6 ft. long, and bent in the way shown in Fig. 1. About 2 ins. are bent down at each end, and a ring to which the cord from the supplementary kite is tied is formed about 6 ins. from one end. The wire is passed spirally some fifteen to twenty times round this wire, and with this number of turns the clamp is perfectly secure. It is very rapidly put on and taken off, the absence of nuts or screws being a great advantage, and it cannot injure

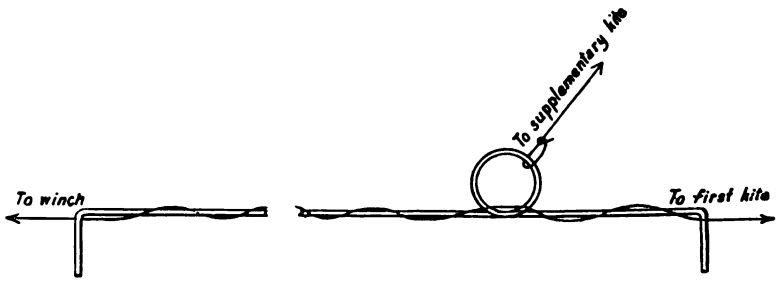


FIG. 1.

the wire. I wish for no better or more simple or more convenient clamp.

Monsieur Teisserenc de Bort kindly supplied two recording instruments and lent another. These are somewhat similar in principle to Richards'. The temperature pen is actuated by a steel-brass couple instead of by a Bourdon tube filled with spirit. This is undoubtedly more sensitive, although I do not consider that any appreciable error is introduced by the lag of the Bourdon tube in Richards' instruments. A Stevenson thermometer screen was fixed in front of the vessel, and the instruments when not in use were kept in this screen, together with a dry and wet bulb thermometer. Constant readings were taken both before and after each ascent, and the thermograph readings nearly always agreed with them to within 1°. Hence, apart from the question of lag, which affects a mercurial thermometer as well as a thermograph, the temperatures may be taken as substantially correct. As in the previous year, the hygrometer records cannot be depended upon to give the precise relative humidity. The hairs were exposed, and on one of the occasions when the instrument came down dripping with water from the rain it was, as a test, carried into the stoke-hole, where the temperature was over 80°. The thermograph responded instantly, but the hygrometer continued to indicate complete saturation for about five minutes, that being the time required for the water to dry off the hairs. I think that these hairs should be protected from rain, even though it be

at the expense of the thorough ventilation secured by leaving them in the open.

The results of the summer's work are given in the following tables, and there are added thereto a few temperatures obtained at Oxshott during the preceding winter :—

TEMPERATURE OBSERVATIONS AT CRINAN, 1903.

August 6.—3.30 p.m. Wind W. below, force 6-7 ; N.W. by W. above. One kite 7 ft. 6 ins. Temperature pen jammed so that record is doubtful. Kite reached 3300 ft., instruments 2450 ft. Temperature decrease about 14° and uniform, humidity increasing above. Cumulus clouds with passing showers.

August 10.—Wind 5 to 6, W.N.W. One small and one medium kite.

Time.	Height.	Temperature.	Time.	Height.	Temperature.
a.m.	ft.	°	p.m.	ft.	°
11.40	650	57	12.25	3900	48
11.45	1200	54	12.30	4500	48
11.50	1300	54	12.35	5200	42
11.55	1800	53	12.40	5200	38
12.0	1900	52	12.45	4600	39
p.m.			12.50	3800	39
12.5	1900	51	12.55	2600	45
12.10	2200	50	1.0	1700	46
12.15	2700	49	1.5	700	48
12.20	3400	48	1.10	0	52

Pen rather inclined to jam, and hence the temperatures may be a degree or two out. Humidity and wind decreasing above. Good steady breeze.

August 10.—Light breeeze, W.N.W., failing above. One medium kite.

Time.	Height.	Temperature.	Time.	Height.	Temperature.
p.m.	ft.	°	p.m.	ft.	°
6.40	0	56	7.5	1600	48
6.45	600	54	7.10	1700	47
6.50	1200	51	7.15	1900	46
6.55	1500	49	7.20	1000	51
7.0	1500	48	7.25	0	54

Humidity decreasing above.

August 14.—Wind East, force 7. One small kite. 4.30 p.m. Reached height of 2100 ft., the temperature variation not exceeding 4°. Clock stopped at starting. Gale from East in the morning, force 9 in the squalls. In the afternoon the kite was drawn in quickly, as a squall was seen approaching. Wet all day.

August 15.—Wind N.W., force 4-5. One small kite.

Time.	Height.	Temperature.	Time.	Height.	Temperature.
p.m.	ft.	°	p.m.	ft.	°
4.5	0	59	4.45	4300	46
4.10	650	57	4.50	3600	49
4.15	1300	54	4.55	3900	48
4.20	2200	54	5.0	3000	50
4.25	2600	53	5.5	1800	53
4.30	2600	53	5.10	800	55
4.35	2900	51	5.15	0	58
4.40	3200	49			

Wind backing to S.W. Air nearly saturated throughout. Thunder in east at 3 p.m.

August 17.—Wind N.W., force 2-3, backing to S.W. Large kite (12 ft.).

Time. p.m.	Height. ft.	Temperature. °	
4.0	0	56	
4.5	650	53	
4.10	800	53	
4.15	1500	51	
4.20	1600	50	
4.25	1600	50	
4.30	2600	48	Obtained by winding in during dead calm.
4.32	2930	?	
4.35	2000	50	
4.40	0	56	

Air moist throughout. Sky clear save for few cumulus.

August 18.—Wind N.W., force 2-3. Large kite.

Time. p.m.	Height. ft.	Temperature. °	
3.40	0	57	
3.50	900	56	
4.0	1200	55	
4.10	1600	54	
4.20	1200	54	
4.30	1400	54	
4.40	2660	47	Observed height 2680.
4.50	0	57	

Air nearly saturated at the surface, very dry at 1000 ft., then becoming damper again.

Dead calm most of the day. Cirrus coming slowly from S.W.

August 19.—Wind S.W., force 2-3. Large kite and one medium.

Time. a.m.	Height. ft.	Temperature. °	
10.55	6	57	
11.0	650	59	
11.5	1100	57	
11.10	1300	55	
11.15	1900	52	
11.20	2200	50	
11.25	3250	48	
11.30	3250	46	
11.35	3350	45	
11.40	3100	43	Cloud.
11.45	3700	45	
11.50	2300	48	
11.55	2250	?	
11.58	1700	48	Clouds.
p.m.			
12.2	3900	42	
12.5	3550	43	
12.10	4550	41	
12.15	5000	40	
12.20	5850	37	
12.25	5700	36	Observed height 5600.
12.30	4450	38	Heavy shower.
12.35	3850	40	
12.40	2800	48	
12.45	800	51	
12.50	0	61	

Air moist at surface, saturated above. Very fitful wind. Cumulus clouds.

The supplementary kite got into the sea at landing, owing to total failure of surface wind.

August 19.—Wind S., squally. One medium kite.

Time. p.m.	Height. ft.	Temperature. °	
5.12	0	56	
5.17	440	57	
5.22	1780	53	
5.27	2900	50	
5.34	4240	46	
5.37	3650	47	Kite S.W., wind S. by W.
5.39	5300	40	
5.45	4400	43	
5.50	4580	42	
5.57	2230	48	
6.2	500	52	
6.5	0	53	

Air dry from 1000 to 4000 ft. during ascent, but saturated at the same level on descent. Shower in west at 5.10 p.m. Heavy shower at 7.50 p.m. Sea rough.

August 20.—Wind S.S.W., force 6. One small kite.

Time. a.m.	Height. ft.	Temperature. °	
11.8	0	53	
11.13	800	52	
11.18	1600	47	
11.21	2240	44	Observed height 2190 ft.
11.23	2000	45	
11.28	3000	42	Clouds.
11.33	3720	40	Wire lying to the right of the funnel smoke.
11.38	3900	39	
11.40	4450	37	Thunderstorm with extremely heavy rain and hail.
11.43	4100	38	
11.48	1200	46	
11.53	300	47	
p. m. 12.2 p.m.	0	50	

Air saturated throughout. Heavy showers all the morning. The first intimation of thunder was a brilliant flash of lightning in S.W., three-quarters of a mile distant, at 11.42. Rain for a few minutes and hail so heavy that it was hardly possible to see beyond the length of the vessel. Hail about the size of currants. The wind dropped during the storm to a dead calm at times. Sea rough.

August 20.—Wind S.W., force 4-5. One medium kite.

Time. p.m.	Height. ft.	Temperature. °	
5.30	0	57	
5.35	1500	51	
5.40	3000	45	
5.45	3200	44	
5.50	3500	42	Clouds.
5.55	4130	40	Heavy shower.
6.0	3300	42	
6.5	1880	44	
6.10	200	52	
6.15	0	54	

Air dry at starting. Saturated at 4000 ft. and during descent.

August 21.—Wind W.N.W., force 6. One small kite.

Time. p.m.	Height. ft.	Temperature. °	
12.40	0	56	
12.45	400	58	
12.50	1150	56	
12.55	1800	54	
1.0	2000	53	
1.5	2240	49	
1.10	3000	46	
1.15	2800	47	
1.20	3160	43	
1.25	3350	42	
1.30	3790	41	
1.35	4450	39	Observed height 4520 ft.
1.40	?	40	,, ,, 5130 ft.
1.45	?	44	
1.50	4100	45	
1.55	2230	51	Fleecy clouds.
2.0	300	55	
2.5	0	55	

Air dry at starting. Very dry and temperature inversion up to 1200 ft. Moist above 3000 ft. Clear sky save for a few low clouds. Convection currents shown by rapid rise of kite soon after 1.30 p.m.

August 21.—Wind W.S.W., force 5. One medium kite.

Time. p.m.	Height. ft.	Temperature. °	
6.20	0	55	
6.34	3130	42	
6.36	3580	40	
6.38	3700	40	
6.45	4350	36	
6.52	5580	33	
6.53	5500	33	In detached clouds.
6.58	5830	31	
7.0	5900	30	
7.10	...	30	
7.23	5500	34	Below clouds.
7.24	5180	33	
7.29	4200	36	
7.47	0	55	

The barograph pen was jammed and useless, but the sky being mostly clear good observations were obtained, and the heights are those obtained by observation.

Air dry at starting, getting gradually moister and becoming saturated at 5000 ft. Lowest temperature, 26°·5 at about 6400 ft.

August 22.—Wind S.W., force 5. One medium, one small kite.

Time. a.m.	Height. ft.	Temperature. °	
10.55	0	55	
11.0	100	59	
11.5	930	55	
11.10	2340	49	
11.15	2800	51	Air very dry.
11.20	3720	47	
11.25	3720	44	Still under the clouds.
11.30	4840	40	
11.35	4650	42	
11.40	4020	47	

Time. a.m.	Height. ft.	Temperature. °	
11.45	4300	46	
11.50	4100	47	
11.55	3720	47	
12.0 p.m.	2620	53	
12.5	5220	42	
12.10	4460	42	Air saturated.
12.15	3720	45	
12.20	3720	45	
12.25	2070	49	
12.30	830	55	
12.35	0	56	

Maximum height 5500 ft. at 12.2, with temperature 41°. Humidity of the air very variable. Temperature 62° at 200 ft. on descent. Strong convection currents are indicated by the rapid changes of height, especially at 11.25 and at noon.

Showery morning. Sea rough, but weather improving.

August 24.—Dead calm. Large kite.

Time. p.m.	Height. ft.	Temperature. °		Time. p.m.	Height. ft.	Temperature. °	
12.10	0	57	Moist.	12.33	1700	62	
12.16	300	69	Dry.	12.36	2400	57	
12.21	750	63		12.41	840	63	Very dry.
12.26	1100	60		12.44	300	65	
12.28	1300	63		12.47	0	59	Moist.
12.31	1500	64					

Temperature inversion. The rate from 1500 to 2400 ft. is beyond the adiabatic rate, but the two observations were in places nearly a mile apart. The kite was got up in a light catspaw (aided by the tide) from N.W., which soon shifted to N.E. Thunderstorm in afternoon with good breeze for an hour. Tried again in the evening, but failed from total want of wind.

August 25.—Wind W., force 3-4. One medium and one small kite.

Time. p.m.	Height. ft.	Temperature. °	Time. p.m.	Height. ft.	Temperature. °
3.10	...	56	4.15	3170	49
3.15	400	58	4.20	3000	48
3.20	1680	53	4.25	3750	46
3.25	2050	52	4.30	3950	45
3.30	2900	52	4.35	4100	45
3.35	2650	51	4.40	5040	42
3.40	2600	52	4.45	5600	38
3.45	2900	53	4.50	5600	38
3.50	2250	55	4.55	3750	44
3.55	2250	54	5.0	2600	47
4.0	2200	53	5.5	700	55
4.5	3000	49	5.10	...	57
4.10	3250	49			

Air moist at the surface, dry from 2000 to 4000 feet, and then moist again. Maximum height 5800 feet, with temperature of 37° at 4.47. Wind the same direction above and below.

August 26.—Gale S.S.W. all day. Morning, broke one kite in the funnel stays, and another in the sea, and then gave up the attempt. Another attempt in the evening with no better success.

August 27.—Wind S.W., force 6-7. Sent up a kite without the instruments as the weather was getting worse. Wind at 3000 feet W.S.W. Cloud level

over 3000 feet. Gale 8-9 in afternoon. [The vessel was not again available till September 1.]

September 1.—Gale in the morning, moderating in the evening. Kite, without instruments, reached 3650 feet in the evening. Wind S.W. by W. above and below ; cloud level about 3000 feet.

September 2.—Wind East, force 2. Large kite.

Time. p.m.	Height. ft.	Temperature. °	Time. p.m.	Height. ft.	Temperature. °
12.10	...	57	12.40	3150	50
12.20	300	60	12.45	1860	52
12.25	600	57	12.50	500	56
12.30	1850	55	12.55	...	60
12.35	2620	52			

Air moist, with little change throughout. Cirro-stratus in the east. Steady rain, with a dead calm, set in at 2.30 p.m.

September 3.—Wind S.W., force 5. One medium kite.

Time. p.m.	Height. ft.	Temperature. °	
5.35	0	57	
5.40	400	57	
5.45	1870	53	
5.50	3170	47	
5.55	3900	44	Observed height 4030 ft.
6.0	4690	41	Still under clouds, which looked like low clouds.
6.5	5620	36	Clouds.
6.10	6380	34	
6.15	6800	32	
6.20	7200	29	
6.25	7220	29	
6.30	7500	30	
6.35	6700	32	
6.40	7200	31	
6.45	6380	33	
6.50	6000	35	
6.55	6000	36	
7.0	6100	33	
7.5	5620	34	
7.10	4700	37	
7.15	3900	40	
7.20	1980	46	
7.25	100	53	
7.30	0	55	

Air dry on ascent up to 4000 ft., saturated from 5000 to 6500 ft., very dry at the highest point, saturated from 6000 ft. downwards on descent. Sea rough. Wind S.W. at highest point.

September 4.—Lost one kite and instruments. The kite flew well and very steadily until reaching a height of 3500 ft., when it collapsed suddenly, and fell into the sea without diving. Cause unknown. Wind S.W., force 5, but probably a gale outside to judge by the heavy swell. The wire fouled the propeller, and broke, and the kite could not be found owing to the roughness of, and the patches of white on, the sea. Cloud level not reached at 3500 ft.

TEMPERATURES AT OXSHOTT, 1902-1903.

1902.	Time. p.m.		Temp.	ft.	Temp.
Oct. 17	4.30	Surface	51	4250	33
,, 22	3.30	,,	52	1900	45
,, 24	3.30	,,	?	2480	45
,, 31	4.0	,,	49	2400	42
Nov. 6	4.0	,,	55	1700	52
,, 7	3.50	,,	53	3330	37
,, 8	?	,,	50	1560	45
,, 15	4.50	,,	...	1700	50
Dec. 13	...	,,	...	3000	46
,, 27	3.40	,,	49	2500	38
1903.					
Jan. 10	3.0	,,	48	4100	26
	a.m.				
,, 28	11.50	,,	47	1800	57
April 29	11.30	,,	55	2540	43
May 13	11.30	,,	58	2770	45
,, 15	11.50	,,	?	4200	32

The tables, but more particularly the charts, show the unsettled conditions that prevailed. Repeatedly a kite was carried up a thousand feet or more in a few minutes, or dropped the same height by a convection current. Again and again, as soon as a second kite had been put on the line, the wind dropped so that we were compelled to take it off and wind in rapidly to keep the wire clear of the sea, or else one of the frequent squalls of which we had so many was seen approaching. In fact, it almost seemed as though the mere putting on of a second kite were the prelude to one or other of these phenomena. That the kites were carried up and down by ascending and descending currents seems fairly certain, although the same change of height might be produced simply by changes in the velocity of the wind. If the wind be strong enough to support a kite properly, an increase of strength does not raise it, but with a light wind, say one under 15 miles per hour, an increase of strength makes a kite go up. In the majority of the cases referred to the wind was shown to be well over this limit by the pull upon the wire, and hence there can be little doubt that the variations in height were produced by a vertical circulation of the air. The most marked instance of this occurred on August 22nd, when the height changed to the extent of half a mile in five minutes. Were it possible, it would be very interesting to obtain the precise increase of temperature in the ascending currents, but it is difficult where such rapid changes of height and temperature occur to eliminate the effect produced by the lag of the thermograph. There is one chart of special interest, namely, that of the morning of August 20, but the interest is of a negative character. I should not deliberately send up a kite during a thunderstorm, and was therefore the more pleased, when accidentally surprised by one, to recover the instruments safely. There is, however, nothing in any way peculiar about the chart, the temperature gradient being close to its average value. The kite, when the first flash of lightning occurred, was at a height of 4550 ft., 8230 ft. of wire being out, and we had little expectation of getting it back. Full steam was turned on, and the engine left to pull in the wire as fast as it could, since electrical indications could decidedly be felt by any one touching the steam valve. During the winding in what at first appeared to be a squall overtook the

vessel, the appearance being that of a definite wall, behind which nothing could be seen except the white tops of a few breaking waves. It was, however, only rain and hail, and mist produced by the splashing of the rain and hail on the sea. As it passed the vessel the water ran down the deck in sheets, and I do not think I have ever seen rain of such intensity. Some difficulty was experienced with the kite when it was near the vessel, owing to the fitful character of the wind, which several times dropped entirely, and allowed the wire to become slack. No hail occurred at Crinan, some five miles to the north-east, but thunder and very heavy rain. The thunder was not of a severe character or very frequent, but there were several flashes of lightning less than a mile distant. The chart shows that rain of an exceptional character and hail may occur under normal conditions of temperature gradient near the surface. It would have been interesting to have had records from the higher strata, but the time intervals between the lightning and subsequent peal prove that the kite was in the actual region of the electrical disturbance. The temperatures show that the hail must have been produced at a higher level.

The mean temperature gradient for the first 5000 ft. was during last August 3°·2 per 1000 ft. This is substantially the same as that obtained during the preceding summer, although the conditions of weather were very different.

A complete confirmation of the result shown last year with regard to the Ben Nevis temperatures has been obtained. This year, again, every single temperature obtained from the kites at the Ben Nevis level has been above the Ben Nevis temperature. The differences ranged from 3°·0 to 11°·0, Ben Nevis being on the average 6°·0 colder. Separating the observations into those taken before and after 1 p.m., the difference is 6°·6 for the morning and 5°·5 for the afternoon. Last year the average difference was 4°·7. It was found again this year that the South winds increased rapidly in strength with increasing elevation, whereas the North-west winds did not do so. There was again very little change in the wind direction with elevation, whereas in the neighbourhood of London there is generally, as any one may see by the clouds, a marked change. On one point suggested by the observations of 1902 (*Philosophical Transactions of the Royal Society of London*, series A, vol. 202, p. 123), namely, the question of the temperature conditions of cyclones and anticyclones, the ascents were not sufficiently numerous or consecutive to throw further light, a matter that I much regret.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) said that the Society owed its thanks to Mr. Dines and his sons for their zeal and trouble in this important work. He could personally testify to the many difficulties encountered by Mr. Dines in the prosecution of these experiments, and to the extreme ingenuity with which he surmounted them without any skilled mechanical assistance. He had the pleasure of going out with him on two days only, but in that time they experienced every sort of weather except fog.

Dr. W. N. SHAW said that he hoped this paper was not the last that Mr. Dines would have to say on the results of the kite experiments, although perhaps he was looking at the matter from a selfish point of view. It was

necessary to know the relationship between the circulation of the atmosphere above and that below, in order to understand what changes were about to take place. M. Teisserenc de Bort, at the meeting of the British Association at Southport last year, explained the conditions under which the familiar circular movement of storms was a surface condition only, while up above, the isobars were drawn more into parallel lines. In the gale of February 26-27, 1903, the surface distribution was more or less circular, but at the summit of Ben Nevis there was no north side of the system appreciable. In order to take account of the variation of barometric distribution with height in forecasting, it was necessary to know the density of the air in all the phases of surface conditions, but it was difficult to obtain such information for each special case, and thus we were compelled to make an assumption based upon what had happened in previous cases. Again, the opportunity for the study of special conditions was very valuable. The sudden occurrence of the thunderstorm which Mr. Dines experienced on August 20 was an interesting phenomenon, and more details would be of service.

Mr. J. HOPKINSON, referring to the temperatures on Ben Nevis being lower than those shown by the kite records at the same altitude, thought that it would generally be found that lower temperatures obtained on mountain summits than in the free air. Possibly that was an explanation of the continued formation of clouds so often seen on the higher mountain slopes, as the air, free of clouds elsewhere, passed over them.

Dr. R. H. SCOTT remarked that the formation of the cloud at the top of mountains was probably due to the air being forced to rise, by the obstacle to its horizontal motion, and in parting with its heat caused the contained aqueous vapour to condense, and form a cloud.

Mr. J. E. CLARK inquired if it was possible that the expansion and cooling of the air on the top of mountains would account for the lower temperatures being observed there in the summer months than at the same height in the free atmosphere; also whether the ground temperature at high altitudes would be relatively lower in summer than winter.

Mr. W. MARRIOTT said that in 1902 he had an opportunity of witnessing the carrying on of the kite observations at Crinan. He could testify to Mr. Dines' great skill in overcoming any difficulty or obstacle that might arise. This last year was worse than 1902, and the weather and other conditions militated against obtaining so many or such good results. The boat was certainly a bad one, and Mrs. Dines was in fear and trembling each time Mr. Dines went out in it, but, fortunately, no disaster occurred.

Mr. W. H. DINES, in reply to Dr. Shaw, said that he should much like to classify the temperature gradients according to the direction of the wind and the position of the centres of the various depressions, but he had thought that there was hardly sufficient material. A difficulty with regard to the temperature of the convection currents was the unknown amount of the lag of the thermometer. With reference to Dr. Shaw's remark about the absence of the North-easterly part of the storm of February 26-27, 1903, at Ben Nevis, he had always found at Crinan a decrease in the strength of Northerly winds (N.E. and N.W.) with increasing elevation, but a decided increase in the strength of Southerly winds. The thunder-clouds through which the kite had been drawn in were certainly low, since the time interval between the flash and the thunder was short; moreover, the cumulus from which the storm developed was seen approaching, and had the appearance of no great height. With reference to Mr. Hopkinson's remark, he had no doubt but that Dr. Scott had given the true explanation, namely, that the lower temperature of the summit of Ben Nevis was produced by the adiabatic cooling of the air as it was forced up the slope of the mountain.



HOFRATH DR. JULIUS HANN

(*Symons Medallist*, 1904)

SYMONS MEMORIAL MEDAL, 1904.

(Plate IV.)

THE presentation of the Symons Memorial Gold Medal for 1904 was made at the Annual General Meeting of the Society on January 20, the recipient being Hofrath Dr. Julius Hann of Vienna.

THE PRESIDENT (Capt. D. WILSON-BARKER) said: "Before proceeding to award the Symons Medal, I wish to explain that it was founded to commemorate the meteorological work of the late Mr. G. J. Symons, F.R.S., one of our Presidents, whose labours in Meteorology have a world-wide reputation, particularly in the collection of information regarding rainfall. The first Medal was awarded in 1902 to Dr. Buchan, F.R.S. The following is the Extract of the Minutes of the Meeting at which the Council decided this award:—

"Dr. JULIUS HANN was born March 23, 1839, at Schloss Hans, near Linz, in Austria. In 1850 his father moved to Kirchdorf in Kremsthal, and there his son first came to know the mountains, which he subsequently studied so well. In 1864 he became qualified as Teacher of Mathematics and Physics, first at the Obergymnasium of Schottenfeld, Vienna, and later, at Linz.

"In 1867 he was appointed on the staff of the Central Anstalt für Meteorologie at Vienna by Jelinek, and in the same year he with his chief started the *Zeitschrift der Oesterreichische Meteorologischen Gesellschaft*, now known as the *Meteorologische Zeitschrift*, and the recognised organ for the science.

"In 1874 he succeeded Jelinek as Director of the K. K. Central Anstalt für Meteorologie und Erdmagnetismus, a post which he resigned in 1897, and retired to Graz. There, however, he found himself unable to find access to a library sufficiently complete to meet the requirements of his studies. He returned to Vienna in 1900.

"He has received the title of Hofrath from his Sovereign, and is Member of the Academy of Vienna and Honorary Member of many foreign Societies.

"His published works are very numerous. The Royal Society Catalogue has no less than 121 titles to his name. His principal published works are:—

"1. *Allgemeine Erdkunde*, published conjointly with Prof. Hockstetter and Prof. Pokorny. The third edition of this work appeared in 1881. Hann's part of it related to Astronomical Geography, Meteorology, and Oceanography.

"2. *Handbuch der Klimatologie*, which has reached two editions, the second (1897) being of 1364 pages. It is a perfect treasure-house of meteorological information as to the climates of the entire globe.

"3. In 1887 he published the *Atlas der Meteorologie*, forming Part III. of Berghaus' *Physikalischer Atlas*.

"4. Lastly, in 1901 he brought out his *Lehrbuch der Meteorologie*. It is the most thorough treatise in existence on all branches of the science, with references to the original sources of information in all languages. It is a book in every respect what the Germans call 'epoch-making.'"

THE PRESIDENT continued: "I deem it an honour that it is my privilege to present this Medal to Dr. Hann on behalf of the Society. I much regret that he is unable to be present this evening, but we welcome Count Széchenyi of the Austro-Hungarian Embassy, who has kindly come here to receive the Medal on his behalf."

COUNT SZÉCHENYI said that he wished to thank the President for the kind and appreciative remarks that had been made about Dr. Hann. He was very proud of being present in two ways: firstly, in being permitted to take charge of and deliver the Medal; and secondly, for the great honour in receiving it on behalf of so distinguished a fellow-countryman of his as Dr. Hann.

THE FOREIGN SECRETARY read the following translation of a letter which Dr. HANN had sent to the President:—

"Honoured Sir,—I have learnt from a letter from your Secretary that the Council of the Royal Meteorological Society have awarded to me the Medal recently founded in memory of Mr. G. J. Symons, and I have been invited to receive, in person, the Medal from the hands of the President at the Annual Meeting on January 20.

"Unfortunately it is impossible, for many reasons, for me to accept this kind invitation, and to express personally my gratitude for the distinction.

"I therefore address the following request to you, Sir, to be so good as to express to the Royal Meteorological Society, on the occasion of their Anniversary Meeting, my deepest and warmest thanks for the high honour they have conferred on me by the award of the Symons Medal.

"I feel myself specially honoured by the circumstance that the Royal Meteorological Society has made me the second recipient of this distinction, and so has held me worthy to be placed alongside of the distinguished Meteorologist, Alexander Buchan. I beg you to accept the assurance of my profound respect.—Yours, etc., J. HANN.

"VIENNA, *January* 16, 1904."

A portrait of Dr. Hann is given in Plate IV.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 20, 1904.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

CLAYTON BEADLE, Halewood, Sidcup;
HERBERT GARNETT, Maghery, Moy, Co. Tyrone;
CHARLES WHENSA NICHOLL, 33 Hamlet Gardens Mansions, W.; and
WILLIAM IZETT WALKER, 133 George Street, Edinburgh,
were balloted for and duly elected Fellows of the Society.

January 20, 1904.

Annual General Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

Mr. J. N. BEADLES and Mr. J. E. CLARK were appointed Scrutineers of the Ballot for Officers and Council.

The Report of the Council having been taken as read, it was proposed by the PRESIDENT, seconded by Mr. F. C. BAYARD, and resolved: "That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*." [The Report will appear in the next number of the *Quarterly Journal*.]

It was proposed by Dr. H. N. DICKSON, seconded by Mr. A. BREWIN, and resolved: "That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year, and also to the Auditors."

It was proposed by Dr. C. T. WILLIAMS, seconded by Mr. F. DRUCE, and resolved: "That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

THE PRESIDENT, having read the Minute of the Council awarding the Symons Gold Medal to Hofrath Dr. JULIUS HANN, of Vienna, in consideration of his eminent services to the science of Meteorology, presented the Medal to Count L. SZÉCHENYI, the First Secretary to the Austro-Hungarian Embassy, who was present to receive the same on behalf of Dr. Hann (p. 167).

The PRESIDENT then delivered an Address on "THE PRESENT POSITION OF OCEAN METEOROLOGY" (p. 105).

It was proposed by Mr. B. LATHAM, seconded by Mr. R. BENTLEY, and resolved: "That the thanks of the Society be given to Capt. D. WILSON-BARKER for his services as President and for his Address, and that he be requested to allow the Address to be printed in the *Quarterly Journal*."

The SCRUTINEERS declared the following gentlemen to be the Officers and Council for the ensuing year:—

PRESIDENT.

Capt. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

VICE-PRESIDENTS.

WILLIAM HENRY DINES, B.A.
JOHN HOPKINSON, Assoc.Inst.C.E., F.R.M.S.
HENRY MELLISH, D.L., J.P., F.R.G.S.
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February 17, 1904.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

Rev. WILLIAM CHARLES EPPSTEIN, M.A., School House, Reading;
THOMAS GREEN, St. Anne's Road, Horwich, Lancs.;
N. V. IYYA, 48 Coral Merchant Street, Madras;
W. MATERN, Johannesburg, Transvaal; and
T. EDMONDSTON SAXBY, L.R.C.P., Halligarth, Baltasound, Shetland,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1903." By EDWARD MAWLEY, F.R.Met.Soc. (p. 123).

"OBSERVATIONS BY MEANS OF KITES AT CRINAN IN THE SUMMER OF 1903." By W. H. DINES, B.A., F.R.Met.Soc. (p. 155).

CORRESPONDENCE AND NOTES.

Rainfall over the British Isles.—At the meeting of the Institution of Civil Engineers on November 24, 1903, Dr. H. R. Mill read an important paper on "The Distribution of Mean and Extreme Annual Rainfall over the British Isles." The data employed was that collected by Mr. Symons, and published in the annual volumes of *British Rainfall*. The author began by pointing out the methods he had employed to ascertain what period of observation was most likely to yield as near as possible the true mean. He came to the conclusion that the 30 years' period 1870-99 was the most suitable to adopt, and it had the advantage that the number of stations during that time was greater than in any earlier period. The figures for England and Wales, which were most numerous, were plotted on a map on the scale of 16 miles to an inch, those of Scotland and Ireland on a map on the scale of 28 miles to an inch, and after the isohyetal lines were drawn they were all transferred to this smaller scale. Lines were drawn for each 5 inches of rainfall up to 40 inches, for each 10 inches up to 60 inches, and after that for each 20 inches. The map of mean rainfall which Dr. Mill now puts forward does not at the first glance differ greatly from its predecessors, but he maintains that it has at least the advantage of being founded upon a more homogeneous and longer series of observations than has ever been brought together previously.

The average rainfall of the country is shown to be—

	Ins.		Ins.
England . .	31·62	Scotland . .	46·85
Wales . . .	49·53	Ireland . . .	42·28
Isle of Man . .	34·66		

British Isles 39·25 ins.

Dr. Mill next discussed the question of the extremes of annual rainfall, and found that on the whole 1872 was the wettest year, and 1887 the driest year over the British Isles during the period under review. He accordingly prepared rainfall maps for these years in the same manner as the map of average rainfall. The following figures show by ratios the excess and defect of the extreme years compared with the mean, and the difference between the two extreme years :—

	Mean.	1872.	1887.	Difference.
England . . .	100	143	74	69
Wales	100	149	74	75
Scotland . . .	100	133	84	49
Ireland . . .	100	124	76	48
British Isles . . .	100	134	77	57

The paper, which is printed in the *Minutes of Proceedings of the Institution of Civil Engineers*, vol. **155**, part 1, is followed by an interesting discussion which occupied two evenings, and the whole is rendered still more valuable by correspondence from several distinguished meteorologists, Prof. Cleveland Abbe and Dr. Julius Hann being included.

London Fog Inquiry, 1901-2.—At the request of the London County Council the Meteorological Council undertook to carry out an inquiry into London fogs during the winter of 1901-2. Capt. A. Carpenter, who had charge of the inquiry, has presented his *Report* to the Meteorological Council. The observations were made by the officers of the Metropolitan Fire Brigade at thirty fire stations, as well as by a number of other observers.

The order of fog frequency on days of the week during the winter in question works out in the following order :—

Friday	163	Tuesday	115
Saturday	143	Thursday	112
Sunday	143	Monday	87
Wednesday	139		

The time of commencement of fog generally appeared to be simultaneous over London, although it slightly favoured low-lying stations. The following were the hours of commencing to form on forty-three occasions :—

Midnight to 1 a.m.	3	9 a.m. to 10 a.m.	2
5 a.m. to 6 a.m.	8	5 p.m. to 10 p.m.	7
7 a.m. to 8 a.m.	23		

Fogs in London were dispersed when the record of wind at the Kew Observatory reached a velocity of 13 miles per hour, except the very smoky fogs accompanying the damp air of advancing depressions, and these seemed to require a force of about 17 miles an hour to dislodge them.

Capt. Carpenter says that there are only three causes of fog, viz.—(1) a warm atmosphere cooled by contact with a cold earth or water surface, which forms a cold surface fog ; (2) a cold atmosphere warmed by contact with a warm earth or water surface, which forms a steaming water fog ; and (3) two atmospheres of different temperatures in contact with one another, which form a cloud fog. Any of these fogs may become permeated by smoke, and the fog particles becoming coated with oily hydro-carbons are then impervious to the evaporating power of the sun's heat, and may drift long distances, but they slowly settle on ground, houses, and clothes, and are inhaled by all living creatures and plants. That there is a downward movement of smoky moisture-laden air seems to be most probable, but to what extent a general downward movement of air takes place under anticyclonic conditions has not yet been discovered.

Climate of the Philippines.—In the *Bulletin* of the American Geographical Society for June, Mr. Walter S. Tower gives some notes on the climate of the Philippines, based on the observations made at Manila from 1885 to 1898. The climate may be summarised as follows :—High temperature throughout the year ; small annual and relatively small diurnal ranges ; humid, with excessive rainfall at times ; at certain seasons violent tropical storms. There is a wet season from June to October, and a dry season from November to May, but this does not imply that the dry season is absolutely without rain, nor that there is a continual downpour in the rainy season. There is a minimum of rain in the months from January to April, with the absolute minimum in February ; and there is a maximum of rain in July, August, and September, with the absolute maximum in the last month. The North-east Trade-wind blows during the greater part of the year, the so-called South-west Monsoon being felt during the four summer months, June, July, August, and September, while May and November have variable winds. The typhoons often cause much damage along the low-lying coasts, and a great deal of careful work has therefore been done at the Manila Observatory, in order to bring the prediction of these storms to the greatest possible degree of accuracy. With this object the Director of the Observatory has invented a so-called baro-cyclonometer, an ingenious association of an aneroid barometer and a cyclonometer. Between 1880 and 1898, 397 typhoons passed near enough to the Observatory at Manila to make their influence felt there, February being the only month in which none occurred. The "tornadoes" of the Philippines are not the same phenomena as the well-known western storms of the same name in America,

but are like ordinary thunderstorms. A yearly average of 505 occurred at Manila during the ten years from 1888 to 1897. In December, January, and February the Philippine climate is at its best, the temperature and the humidity both being low, the rainfall light, the night cool, and storms least frequent. During the remainder of the year the conditions of heat, humidity, heavy rains, and the greater prevalence of contagious diseases are undoubtedly very trying for North Americans, and probably few will settle permanently in the Philippines.—*Scottish Geographical Magazine*, December 1903.

Climatic Influence on Vineyards.—During the occupation of England by the Romans, which lasted about four hundred years, they planted vineyards in various places over the southern part. They found the climate suitable for ripening of grapes, and made wine. They were accustomed to this branch of agriculture. After their evacuation of the country the vineyards were kept up by the Saxons, and eventually came under the control of the Conqueror. William I. ordered a survey of all estates in England, and the results were compiled in the historical work known as *Domesday Book*, begun in 1080 and finished in 1086. Mr. L. R. M. Strachan, M.A., has been good enough to search the work, extract the entries of vineyards, and compile the annexed list.

The vineyard-period in southern England is not entirely unworthy of the attention of meteorologists. Its rise and decline afford indication of fluctuation in climatic conditions. The list may have some local interest for meteorologists in southern England. It may be well to add that the arpent was probably variable, but generally half an acre.

"In the reign of Henry II. (1154) a contemporary writer speaks of the district round Thorney as a very paradise in pleasure and delight; it resembles heaven itself—it abounds in lofty trees, neither is there any waste place in it; for in some parts there are apple-trees, in others vines, which either spread upon the grounds or run along poles" (*Social England*, 4, 118).

These vineyards were maintained for about twelve centuries. Nevertheless, and notwithstanding acclimatation, which the plant might be supposed to have acquired, the vine ceased to flourish here, and vineyards for the most part were deleted during the thirteenth century. At the present time the vine flourishes in regions where the mean temperature of summer attains 65°, and that of the winter 40°, as the northern limit in Europe. Probably these were the temperatures in southern England during the vineyard-period when the country must have enjoyed warm, sunny summers.

The suppression of the vineyards has been attributed to the importation of foreign wines, which were better than the English; but it is not improbable that change of climate had something to do with it. The cultivation of the vine has retrograded southward, cannot now be managed farther north than the fiftieth parallel, and not profitably beyond 48° N. in western Europe. It would seem that there has been a lowering of temperature during some four or five centuries, which has been recovering itself as slowly since the latter part of the eighteenth century; for some reliance should be attached to Glaisher's investigation of temperature during the hundred years ending 1865, which tended to show that the climate had become warmer, not only in the summers, but in the winters as well, and indeed in all the months. It is a common belief that winters are not so severe as they formerly were. What are called "old-fashioned winters" were said to have been characterised by prolonged snow, hard frost, keen winds, and clear skies; whereas, in recent years, winters have been mild, damp, and gloomy. Temperature may have long-period oscillations and rainfall also. The success attending Lord Bute's vineyard tends to indicate a rise of thermal influence. Opinions have often been expressed that the climate of northern Europe must have undergone changes during historic time, by some

A Summary View of the Vineyards in "Domesday."

County.	Hundred.	Manor.	Vineæ.	Remarks.
Bedfordshire .	...	Etone . .	2 acres	
Berkshire . .	...	Bisteham . .	12 arpents	
Cambridgeshire	...	Ely . . .	3 ,,	Lands of the Abbey.
Dorset . .	...	Derwinestone .	2 acres	
,, . .	...	Odetun . .	2 arpents	
Essex . .	½ Frossewell .	Ascenduna .	1 acre	
,, . .	½ Thunreslan .	Belcamp . .	11 arpents	1 arpent portat.
,, . .	Wolesfort .	Deppedana .	4 ,,	2 portantes; 2 non-portantes.
,, . .	Hidingford .	Haingleham .	6 ,,	
,, . .	Witbrietesherna	Munduna .	2 ,,	
,, . .	Rochford . .	Rageneia . .	6 ,,	Et reddit xx modios vini si bena procedit.
,, . .	Hidingford .	Seanburne and Topesfeld	1 ,,	
,, . .	,, .	Stabinga . .	2½ ,,	½ arpent portat.
,, . .	Chelmsford .	Waldham .	10 ,,	
Gloucestershire	Blachelew .	Stanhus . .	2 ,,	
Hertfordshire .	...	Berkhamstead .	2 ,,	
,, .	...	Standone . .	2 ,,	
,, .	Brachinges .	Waras . .	4 ,,	Nuperrime plantatæ.
Kent . .	...	Certh . .	3 ,,	
,, . .	...	Cistelet . .	3 ,,	
,, . .	...	Esledes . .	2 ,,	
Middlesex .	...	Chenstone .	8 ,,	Noviter plantatæ.
,, .	Osuluestane .	Chenesit . .	3 ,,	
,, .	...	Coleham . .	1 ,,	
,, .	...	Hermodesworde	1 ,,	Lands of Holy Trinity Church, Rouen.
,, .	Osuluestane .	Holeburne .	...	Willelmus camerarius reddit vicecomiti regis per annum vi solidos pro terra ubi sedet vinea sua.
,, .	Speletorne .	Stanes . .	2 ,,	Lands of Westminster Abbey.
,, .	...	Westminster .	4 ,,	Noviter plantatæ.
Somerset . .	...	Glastonbury .	3 ,,	Abbey lands.
,, . .	...	Langporth .	7 acres	
,, . .	...	Mere (an island)	2 arpents	Land of the Abbey of Glastonbury.
,, . .	...	Michelenie, Midelenie and Torleie	1 ,,	Islands, land of St. Peter's Church, Michelenie.
,, . .	...	Wadeneberie .	3 ,,	An island, land of the Abbey of Glastonbury.
Suffolk . .	Bosemere .	Berchingas .	2 ,,	
,, . .	Risebruge .	Clara . .	5 ,,	
,, . .	Brademere .	Giswortha .	3 ,,	
,, . .	...	Lavenham .	1 ,,	
Surrey . .	...	...	...	Walterus Vinitor holds one hide.
Wiltshire . .	...	Bradford . .	1 ,,	
,, . .	...	Lacoch . .	½ ,,	
,, . .	...	Tollard . .	2 ,,	
,, . .	...	Wilcote . .	...	Vinea bona.
Worcestershire .	Oswoldeslaw .	Hantun . .	...	Vinea novella.

for the better, by some for the worse, though there may have been changes by alternations.

Dr. M. T. Masters, in the *Encyclopedia Britannica*, 9th edition, 1889, says: "The vine requires a high summer temperature and a prolonged period in which to ripen its fruit. Where these are forthcoming it can be profitably cultivated, even though the winter temperature be very low. . . . At the present time the limit of profitable cultivation in Europe passes from Brittany, lat. 47° 30′, to beyond the Rhine by Liège and through Thuringia to Silesia in lat. 51° 55′ (Grisebach). In former centuries vines were cultivated to the north of this region, as for instance, in Holland, in Belgium, largely, and in England where they might still be grown. Indeed, experiments have lately been made in this direction near Cardiff in South Wales. The yield is satisfactory, and the wine made, the variety known as *Gamay noir*, is described as being like still champagne." These experiments were instituted by the late Marquis of Bute, and he is said to have made his venture profitable.

The *Spectator*, September 22, 1894, gave some interesting facts here abridged: East Smithfield was converted into a vineyard and held by four successive Constables of the Tower, times of Rufus, Henry I., and Stephen. In the time of Richard II. the Little Park at Windsor was taken for a vineyard to supply the Castle.[1] The terraced vineyard at Beaulieu Abbey was used for wine-making till the middle of the eighteenth century by John, Duke of Montagu, and at Arundel Castle the manufacture continued till the second half of that century. The last place in which good wine was commonly made from vine-yard grapes was Kensington (part of site now covered by Addison Road Station) as late as 1760. A vineyard existed at Parson's Green, from which, in 1765, 14 hogsheads of wine were expected. After more than a century the Marquis of Bute made a vineyard, in 1875, at Castle Coch, 4 miles from Cardiff, in sight of the Bristol Channel. Three acres were planted, and after two years the first wine was made, 250 bottles of good quality, a rich wine full of body resembling Tokay rather than the lighter growths of France. Three seasons, those of 1879, 1880, and 1886 were total failures; two more were nearly as bad. Good vintages were 1881, when the whole yield sold for £3 per dozen; 1890, when the yield was 2000 bottles; 1884 and 1885, when the yield was 1500 bottles each year; and 1893, when the hot summer produced 12,000 bottles, equal to the whole amount pressed since the vines were established, representing a value of £3000.

In the *Smithsonian Report* for 1877, p. 334, there is a statement which may have some collateral interest with the present subject. It refers to New Mexico during the period elapsed since the end of the twelfth century:—"It is probable that the climate has become progressively more dry as time has elapsed, from evidences of former cultivation which would be now impossible. At Quivira, Dr. Loew says, when Coronado visited this province it was, as he described it, very fertile, at present it resembles a desert." — RICHARD STRACHAN, F.R.Met.Soc.

Rainfall at Ebbw Vale Waterworks.—Mr. T. J. Thomas, Assoc.M.Inst.C.E., has sent the accompanying table of monthly rainfall at the Ebbw Vale Waterworks, Brecknock, for the 21 years 1883-1903. The rain-gauge is 1413 feet above sea level.

The wettest year was 1903 with 82·48 ins., and the driest year 1889 with 39·55 ins.

[1] "As late as the reign of George the Third a little vineyard existed on the outside of the south wall of the lower ward of the Castle, between it and the Castle Hill, east of Henry VIII.'s gateway, a spot now covered with grass."—Tighe and Davis, *Annals of Windsor*, vol. 2, p. 534. (Also a plan of same, *ibid.*, vol. 1, p. 35.)—EDITOR.

Month.	1883.		1884.		1885.		1886.		1887.		1888.		1889.		1890.		1891.		1892.		1893.	
	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.
	in.		in.		in.		in.		in.		in.		in.		in.		in.		in.		in.	
January	**9·59**	**22**	**11·48**	20	6·38	17	5·92	21	4·48	**19**	2·14	11	2·42	14	**11·68**	**26**	5·72	17	2·59	16	3·43	16
February	8·19	21	7·21	**22**	8·24	**22**	1·57	12	1·90	9	·47	6	1·97	16	1·18	11	·12	3	2·59	16	**7·70**	24
March	1·65	8	5·57	17	2·01	11	8·37	14	2·64	11	5·59	15	2·73	16	3·54	19	2·80	**19**	1·30	6	·66	5
April	1·53	7	2·12	10	4·73	14	3·83	17	1·86	10	3·02	16	4·62	22	2·34	17	3·54	12	1·49	11	·27	4
May	2·95	12	2·90	16	4·08	**22**	7·11	19	2·87	15	3·36	11	3·98	**22**	3·55	18	4·76	**23**	2·15	17	4·56	12
June	5·27	18	2·36	8	3·53	13	·82	8	·78	4	5·31	18	·65	7	3·97	22	4·22	15	4·17	16	1·62	9
July	5·22	18	5·56	21	1·59	7	4·40	18	2·57	13	8·01	**27**	5·50	16	3·70	24	2·99	17	3·14	14	4·68	16
August	3·43	14	3·75	12	3·68	15	2·77	10	3·13	9	4·97	19	4·46	19	4·99	21	9·49	**22**	**6·71**	**22**	4·59	15
September	7·08	18	4·12	17	**8·55**	**25**	5·95	17	5·80	16	1·34	11	1·72	12	2·73	12	4·08	21	4·57	20	2·90	14
October	7·56	17	1·94	14	7·14	23	**8·98**	**25**	2·64	14	3·05	15	**5·66**	**26**	2·56	20	**14·37**	**24**	4·25	20	4·73	21
November	7·65	**22**	3·17	16	7·97	18	6·54	20	**6·58**	**19**	**11·50**	**30**	2·51	18	6·67	24	6·17	19	5·26	19	2·98	16
December	3·47	13	9·67	20	2·19	15	8·34	21	4·92	18	8·70	23	3·33	17	1·34	15	11·80	22	3·09	15	7·59	**25**
Year	63·59	190	59·85	193	60·09	202	64·60	202	40·17	157	57·46	202	39·55	205	48·25	228	70·06	214	41·31	192	45·71	177

Month.	1894.		1895.		1896.		1897.		1898.		1899.		1900.		1901.		1902.		1903.	
	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.	Rain-fall.	No. of days.
	in.		in.		in.		in.		in.		in.		in.		in.		in.		in.	
January	7·31	**24**	4·00	20	1·64	16	3·67	14	2·64	15	**11·16**	**25**	6·64	23	3·89	**23**	2·75	19	9·73	25
February	6·63	21	·04	2	·81	12	5·13	20	3·40	23	7·10	14	6·38	20	2·13	14	2·48	11	6·27	21
March	5·11	14	5·33	19	3·91	**25**	8·93	**24**	1·56	13	2·64	11	1·06	10	4·32	17	3·50	17	11·37	29
April	3·79	21	2·88	14	·77	15	5·31	21	4·30	14	6·58	24	2·69	16	5·99	18	4·03	12	2·81	13
May	3·14	21	·62	5	·84	4	2·68	12	5·34	21	4·48	17	3·83	14	1·72	10	3·19	22	6·02	20
June	2·23	15	1·14	8	2·76	14	3·59	14	2·94	17	1·96	9	3·72	17	2·87	11	5·21	18	2·59	11
July	4·95	20	5·48	16	1·96	11	3·08	9	1·14	8	·94	10	2·56	12	2·59	12	2·18	11	3·22	17
August	3·31	19	4·43	19	1·53	16	10·24	**24**	5·55	19	1·60	9	5·49	19	3·53	18	4·38	**23**	8·61	23
September	1·96	9	1·84	10	6·94	**25**	5·96	15	1·78	11	4·48	22	2·12	12	3·81	22	3·53	13	6·80	20
October	6·44	15	2·30	15	4·22	22	3·88	10	8·66	**24**	5·63	11	8·35	21	3·92	**23**	5·90	18	**15·78**	**31**
November	**7·91**	20	**9·70**	23	1·41	9	5·28	15	6·32	23	5·10	12	6·90	25	2·90	11	**6·64**	20	2·85	21
December	3·21	20	4·85	**25**	**11·16**	24	**14·28**	21	**10·89**	23	5·03	19	**10·46**	**28**	**8·57**	22	5·21	18	6·43	22
Year	55·99	219	42·61	176	37·95	193	72·03	199	54·52	211	56·70	183	60·20	217	46·24	201	49·00	202	82·48	253

The greatest monthly fall was 15·78 ins., with 31 rainy days in October 1903, and the least monthly fall 0·04 in., with 2 rainy days in February 1895.

The number of days on which 1 in. and upwards fell were :—

	In.		In.		In.
1884	13	1891	14	1898	7
1885	9	1892	7	1899	13
1886	12	1893	7	1900	10
1887	8	1894	6	1901	4
1888	7	1895	8	1902	5
1889	2	1896	3	1903	18
1890	3	1897	14		

International Meteorological Conference 1905.—Dr. Hildebrandsson informs us that the International Meteorological Committee, at their meeting at Southport in September last, decided to arrange for the holding of a general Conference of Directors at Innsbrück, Austria, in the second week of September 1905.

This Conference will be similar to those at Rome in 1879, Munich in 1891, and Paris 1896.

Jubilee of the French Meteorological Society.—The fiftieth anniversary of the founding of the Société Météorologique de France was celebrated at Paris on June 2, 1903. On behalf of this Society a telegram was sent as follows: "The Royal Meteorological Society, London, sends heartiest congratulations on Jubilee.—WILSON-BARKER, President." The following reply was received: "Sincère et cordial remerciement de la Société Météorologique de France.—MOUREAUX."

At the Meeting of the Société Météorologique de France on the same day Monsieur Violle, the President, delivered an Address reviewing the origin of the Society, the principal events of its existence, the tasks it has accomplished and those which now present themselves to its activity. The following translation of the Address is taken from the *U.S. Monthly Weather Review* for September 1903 :—

The history of the Society has been recently brought to your attention by my illustrious colleague M. Georges Lemoine. I can add nothing to his masterly essay, but wish simply to render homage to the founders of the Meteorological Society of France, and, in order to make this worthy of them, I will quote the words of our regretted colleague Renou, telling how, in the spring of 1852, wishing to publish a series of meteorological observations, carefully collected by him in Versailles, he learned that for several years past a meteorological annual had been published in that city :—

"Three men, without private fortune, but devoted to science, according to Renou, courageously undertook, at their own risk, this publication in the year 1848, with the generous co-operation of the publishers, Gaume Frères. These three men were Hoeghens, Martins, and Bérigny. I was not acquainted with them. I hastened to Versailles. They told me that, notwithstanding all their devotion, they could not continue so onerous a publication. I expressed to them the regret that such a decision caused me, but at the same time indulged the hope that the necessary funds might be procured by founding a Meteorological Society, and I proposed to present them to Charles Sainte-Claire Deville, after having previously conferred with him. This I did. Charles Sainte-Claire Deville received the proposition warmly, and promised to take an active interest in it. He called to his aid Bravais and d'Abbadie, and on August 17, 1852, a successful appeal was made to the scientific world."

One hundred and forty-four persons responded to the invitations of the founders. Among these were Babinet, Becquerel, Elie de Beaumont, Belgrand,

Brongniard, Chatin, Daubrée, Dumas, Geoffrey Saint-Hilaire, Milne-Edwards, Pouillet, Ritter, and, soon afterwards, Le Verrier, to cite only the most illustrious.

The first meeting, where the constitution of the Society was adopted, took place December 14, 1852. Bravais was President, and Charles Sainte-Claire Deville, Secretary. After three other preparatory meetings, on February 15, 1853, the Society inaugurated its scientific sessions, which, as the proceedings show, were already of great interest.

The history of the Society is contained in its Annuaries, the fiftieth of which has just been published. There all the acts of its civil existence may be followed, from its birth up to the time of its declaration of public utility (May 26, 1869), and thence to the time of its Golden Jubilee, which we celebrate to-day. As to its scientific life, this is attested by the numerous and learned memoirs with which M. Georges Lemoine recently entertained you, as well as by the series of observations collected with unceasing care at nearly every point in France.

The series of observations previous to the year 1878 must be sought in our Annuaries, since it was in that year, thanks in great part to the efforts of the Meteorological Society and of its zealous President, Hervé Mangon, that the Bureau Central Météorologique de France was established. One of its duties is to centralise and publish these observations, and the scrupulous exactness with which this laborious task is to-day accomplished gives a special interest to the long series of observations at Versailles, which are of such great utility as a control for the values obtained in Paris. Again, it is in our Annuaries that the first series of the precise observations made at Parc Saint Maur since 1872 are to be found. Being desirous of collecting all the data—those given by ordinary instruments as well as those furnished by the phenomena of vegetation—the Society published in addition, each year from 1868 until the establishment of the Central Bureau, a volume of meteorological items (*Nouvelles*) which contains valuable information for the history of the time.

But perhaps the most important service that our Society has rendered to science is its unceasing effort to obtain accurate observations. The utility of pursuing, beyond certain limits, data of temperature and barometric pressure may be disputed, but the person who makes the observations is certainly bound to give to them all possible accuracy. From the publication of the first Annuaire, the attention of the observers has been earnestly directed to this point, and during fifty years Renou has made active warfare against bad observations. To him are due the first *Instructions Météorologiques*, which were published at the expense of the Meteorological Society in 1855, and which still remain a standard even after the remarkable *Instructions* marked out by M. Angot.

The Society will continue to maintain among its members a bond of esteem and sympathy; it will publish their works with gratitude, and faithfully record their observations. Devoted equally to works requiring many years, and to new ideas, it will faithfully prosecute the fundamental observations which seem to be as necessary to meteorology as to astronomy, and will courageously follow such paths of activity as offer themselves. There are certain questions which are of special interest:—

1. The decrease of temperature with altitude in our atmosphere, only vaguely appreciated up to this time, but which now seems clear to us in its essential features, up to the heights of ten or fifteen kilometers (6-9 miles), thanks to the valuable researches of our colleague M. Teisserenc de Bort. The results already obtained are a sure guarantee of progress in the future.

2. The general circulation of the atmosphere, as to which a real inspiration had enlightened us as far as the information collected at the surface of our globe allowed, is now placed clearly before our eyes by the methodical observations of the clouds and the direct determination of the upper currents.

3. Is it necessary that I should tell you of the rôle played in these studies by mountain observatories, balloons, and kites? The advantages which meteorology will derive from the exploration of the upper atmosphere are fully as great as those offered to geology by delving into the deep mines. However important the mountain observatories may be, it is certain that the influence of the surface of the earth modifies the atmospheric phenomena to a certain extent. Neither the wind, the temperature, nor the electric condition appear as they would at the same elevation above a vast plain. Both the balloon and the kite avoid this objection almost entirely, and enable us to make actual soundings in the free atmosphere at much greater heights than can be obtained by even the most elevated observatories. The repetition of the soundings at the same place, and their agreement at different points, furnish a control which formerly seemed reserved to stationary observatories established in order to secure direct observations at a permanent location.

The success of these explorations of the atmosphere inspires the desire to ascend higher and higher. So many are the problems that are luring us up.

4. We know to-day, beyond all manner of doubt, that there are certain light gases which, although nearly absent from the surface of the ground, prevail in the upper strata. What is the composition of the air at different elevations?

5. We know that an intense ionisation is produced by the solar rays, and is extinguished in the upper atmospheric strata. What are the consequences of this phenomenon? Is the key to the storms to be found in it?

6. At the same time the solar radiation appears to us as manifestly the direct cause of all the phenomena. Its study imposes itself upon us as the surest means of determining the true nature of our sun. Is it a variable star? Is it continually decreasing? These questions are of the first importance for the very existence of our planet.

From a nearer point of view, is it not evident that if we knew certainly the laws of this complex radiation, and the manner in which it acts upon our atmosphere, we could deduce from this the weather conditions at a certain fixed time? And this assuredly is the real problem of meteorology.

There is plenty of work for every one, my dear colleagues. Each of us should do his best on the problems which interest him most, and should make every effort to maintain for the Meteorological Society of France the high reputation which it has acquired during the first fifty years of its existence.

Climate of Northern Nigeria.—The *Geographical Journal* for January contains a paper by Sir F. D. Lugard, High Commissioner, on the physical characteristics of Northern Nigeria. As very little information regarding the meteorology of that part of the world has been published, it may be of interest to reproduce what Sir F. Lugard has to say about the weather of the country:—

"Nigeria is a land of tornadoes. Towards the end of the dry season—end of February—cyclones from the North-east, usually accompanied by storms of thunder and rain, burst with great fury. Increasing in frequency, they merge into the heavy rains which last from July to October. With the cessation of the rains, the whole Sudan presents a vista of grass fires, and the Harmattan wind begins to blow from the North-east. The clear atmosphere of the rainy season gives place to a thick haze, which, like a London fog, obscures the whole horizon, and objects only a few hundred yards distant are indiscernible, so that surveying is difficult. The sun disappears like a crimson disc about 5 p.m. behind this pall of haze, which consists chiefly of impalpable dust. The so-called Tuareg 'veil' and the habit of wearing the pugari over the mouth and eyes is adopted as a protection against this dust. The wind itself blows intermittently for several days with violence, and anon with moderate force or

abates altogether, but always from the same quarter, especially between 8 a.m. and 4 p.m.

"The Harmattan is the herald of cold nights, and in the northern states, even during the day, in the months of January and February, the cold is often trying. The excessive dryness of this wind from the desert of the Sahara causes an evaporation when it meets the wall of humid atmosphere in the Niger Valley, and produces these effects of cold. Where the lakes around Timbuktu and the waters of Chad impinge on the desert, I am told that frost is not uncommon. These cool nights add to the health and comfort of Europeans, and though the Niger Valley is undoubtedly trying, I think that the health conditions of the interior are good, and will improve greatly as our resources enable us to build proper houses and to transport the necessaries for European life and comfort. Even what we have already been able to do has reduced the mortality from 32 per cent in 1898 to 6 in 1901; deaths and invalidings 87 per cent to 34 per cent."

Capt. P. S. Lelean, R.A.M.C., who accompanied the Commission on the Sokoto Arc, Northern Nigeria, has favoured us with a copy of the meteorological observations which he made from April to September 1903. As the Commission moved from place to place the observations were not continuous, the area over which they were taken being a rectangle with measurements of (roughly) 120 by 30 miles. The latitude varied from 14° 28′ to 13° N., and the longitude from 5° 14′ to 7° 36′ E.

The following figures are of extreme interest from this little-known region:—

1903.	Rainfall.		Temperature.	
	Amount.	No. of Days.	Highest.	Lowest.
	ins.		°	°
April	·27	3	...	...
May	·43	4	111·4	66·2
June	2·25	6	112·7	72·2
July	4·69	8	94·7	66·1
August	10·79	12	95·4	64·3
September	4·61	10	...	...

The total rainfall from April 5 to September 30 was 23·04 ins.

Island Stations in the South Atlantic Ocean.—Lieut. H. Ballvé, of the Argentine Navy, announces that the Government of the Argentine Republic has determined to give a permanent character to the first-class Meteorological and Magnetic Observatory on the island of Año Nuevo, situated in the vicinity of the Island des États (Staten Island), in latitude 54° 39′ S., and longitude 64° 7′ 30″ W., which was established in order that the Republic might co-operate with the International Antarctic Expedition.

The island of Año Nuevo is very small, and elevated but little above sea-level, and we have, therefore, been able to instal the observatory under excellent conditions, at a distance of only 6 miles from the mountains of Staten Island. Consequently the observations recorded there must agree essentially with the climate of this region.

A pamphlet giving a full description of the outfit will soon be published; at present it need only be said that the observatory possesses a complete instrumental outfit, such as is appropriate to a station of the first order.

At the end of this present year the observatory will begin the publication of the results obtained during the International Antarctic Expedition, as also of the observations for the present year. Thereafter the results of the observatory will be published regularly.

The observatory of the island of Año Nuevo, as well as the one soon to be established at Bahia Blanca, will form a part of the proposed network of

observatories on the Atlantic coast of the Argentine Republic, under the direction of the Ministry of the Marine.—*Monthly Weather Review*, November 1903.

Sydney Observatory, New South Wales.—We have received the following report of the meteorological work for the year 1903 :—

I. *Forecasting and Map-compiling under Mr. H. A. Hunt.*—The usual daily forecasts have been made with remarkably good results, and the information given is sought after eagerly.

The number of Weather Charts published totalled 18,000, and the Rain Maps of New South Wales 5000 copies.

II. *Climatological Branch under Mr. A. Noble.*—During the year 56 new stations were added to the already large number reporting, now totalling 1847. Of these 31 are barometer stations, 168 temperature, and the balance (1648) rainfall.

We have distributed the following instruments to various stations during the year :—2 hygrometers ; 13 maximum thermometers ; 20 minimum thermometers ; 92 rain-gauges ; 168 measuring glasses ; 3 wind-vanes ; 5 thermometer screens ; 1 large tank evaporator with recording apparatus ; 3 ordinary thermometers.

The manuscript of the *Rain, River, and Evaporation Results* for 1901 and 1902, and the *Meteorological Report* for 1900, 1901, and 1902, has been forwarded to the Government printer, and we hope to distribute these publications to the various exchanging institutions early next year.

III. *Distributions under Mr. W. C. Graham.*—We have distributed Observatory publications this year as follows :—*Rain, River, and Evaporation Results*, 1900 ; *Meteorological Reports*, 200 ; *Current Paper*, No. 7, 231 ; *Weather Charts* (1902), bound, 228 : *Comparison of English and New South Wales Rain*, 231 ; miscellaneous publications, 77 ;—total 2867.

We have received in exchange from foreign observatories 1130 books and pamphlets.

Many of the public institutions, commercial and press offices, received reports of various tabulated matter, weekly and monthly. This absorbs much of the time of the staff.

IV. We have great pleasure in reporting a very favourable prospect for the State of New South Wales, by the continuous and very beneficial rains that have fallen at the right time (the latter half, or early spring and summer), which revived the herbage for the stock, they having been sorely tried during the early part of the year with its terrible drought. Our wheat and other crops have done remarkably well, and we have much to be thankful for.

V. I much regret that Mr. Russell, the Government Astronomer, has been laid up with a very serious illness during the latter part of the year, necessitating his retirement for 12 months from control of the Observatory, and hope that on his return to duty at the end of his leave his health will be such that he will be able to put fresh vigour into his work.

VI. It only remains for me to add that personally I have to thank the officers of the Observatory generally for the attention and ready manner, that they have helped the various work of the institution to a successful issue.

H. A. LENEHAN, *Acting Government Astronomer.*

January 5, 1904.

RECENT PUBLICATIONS.

City of Nottingham. The Meteorology of Nottingham for the year 1903. Compiled by A. BROWN and P. BOOBBYER. Foolscap folio. (8 pp. and pl.)

This pamphlet gives the results of meteorological observations made in Nottingham, and also rainfall registers collected from stations on the watershed of the River Trent in the year 1903. It is accompanied by a large coloured chart illustrating the relations of the numbers of deaths from various causes to the principal meteorological conditions on each day of the year.

Expédition de M. A.-G. Nathorst en 1899. *Recherches océanographiques par Filip Åkerblom.* Uppsala-Universitets Årsskrift, 1903. Matematik och Naturvetenskap III. 80 pp. and 4 pl.

The Swedish expedition which set out in May 1899, under the direction of Mons. Nathorst, for the north-east of Greenland, in the search of Andrée and his companions, also carried out a number of soundings, and observations of salinity, temperature, and drift of the sea currents. This work was entrusted to Mons. Åkerblom, who gives the results in this work.

Examen de la méthode de la prédiction du temps de M. N. Demtschinsky. Par A. KLOSSOVSKY. 8vo. Odessa, 1903. 74 pp. and 6 charts.

It will be remembered that during the past two years M. Demtschinsky has published a journal entitled *Climat*, in which he gives by means of curves the forecasts of weather about two months in advance for a large number of places in various parts of the world. M. Klossovsky has compared these forecasts with the actual weather experienced at Odessa, Kiew, and Moscow. He finds that there is a disagreement to the extent of about 50 per cent. M. Klossovsky recommends that M. Demtschinsky should submit his method to the International Meteorological Committee for an impartial examination.

Hints to Meteorological Observers in Tropical Africa, with Instructions for taking Observations, and Notes on Methods of recording Lake Levels. Published by the authority of the Meteorological Council, 1902. Official No. 162. London, 1902. 8vo. 16 pp. and 2 plates.

This is practically a revised edition of the *Hints to Meteorological Observers in Tropical Africa*, which was prepared by the British Association Committee on the Climate of Tropical Africa in 1891. This Committee made its final report in 1901, and as the Meteorological Council received various applications for advice in regard to the exposure of instruments, they decided to reprint the *Hints* with some slight modifications.

Notes on the methods of recording lake levels have been added. These notes are drawn up by the Hydrographic Department of the Admiralty.

Jelineks Psychrometer-Tafeln erweitert und vermehrt von J. HANN, *neu Herausgegeben und mit Hygrometer-Tafeln versehen von* J. M. PERNTER. Fünfte erweiterte Auflage. Leipzig, 1903. (13 + 108 pp.) 4to.

Dr. Pernter has brought out the fifth edition of the Tables, which are on the model of Wild's in his Russian *Instructions*. Dr. Pernter has added to the Psychrometer Tables, Tables for the Hair Hygrometer.

Observaciones Meteorologicals hechas en el Colegio Maximo de la Compañia de Jesus en Oña, Provincia de Burgos. Oña, 1904. 8vo. (60 pp.)

This contains the daily observations made at Oña in 1903.

Observatoire de Zi-Ka-Wei. Calendrier-Annuaire pour 1904. Chang-Hai, 1903. 8vo. (196 pp.)

This calendar contains, among other things, the magnetic values and notes on the climate of Shanghai.

Observatoire Magnétique et Météorologique de Zi-Ka-Wei (Chine). Bulletin des observations. Tome 27, Année 1901. Chang-Hai, 1903. 4to. (249 pp. and 8 plates.)

This volume is divided into two parts. Part I. deals with terrestrial magnetism, and contains hourly observations of the magnetic declination and vertical and horizontal components. Part II. contains the hourly and other meteorological observations.

Observatoire Royale de Belgique, Service Météorologique. Études sur les nuages, III. Les variétés de l'alto-cumulus, par J. VINCENT. Bruxelles, 1903. 4to. (46 pp. and 6 pl.)

The author describes the various varieties of alto-cumulus, and gives the descriptions of the same by different authorities. The paper is illustrated by a number of phototype pictures of clouds.

Observatoire St. Louis, Jersey. Bulletin des observations magnetiques et météorologiques. X^e^ Année, 1903. St. Hélier, Jersey, 1903-4. 4to. (31 pp.)

This contains the daily meteorological and magnetical observations made at the Observatoire St. Louis under the direction of the Rev. Marc. Dechevrens, S.J.

Pocket Rain Register. Designed by HUGH ROBERT MILL, D.Sc., LL.D. London, E. Stanford, 1904. 32 pp. Size, 5½ by 2½ ins.

In response to many inquiries this register has been designed by Dr. Mill so as to be small enough to go in the pocket and large enough to hold the rain record for a whole year, showing a complete month at each opening. Space is also provided for notes and summaries, and a few useful memoranda and the necessary rules and instructions are added.

Results of Meteorological Observations in New South Wales during 1899. By H. C. RUSSELL, B.A., C.M.G. Published by authority. Sydney, 1903. (72 pp.)

This volume contains the daily observations made at the Sydney Observatory during 1899, and also monthly summaries from fifty stations at various places in New South Wales.

Results of Rain, River, and Evaporation Observations made in New South Wales during 1900. With Maps and Diagrams by H. C. RUSSELL, B.A., C.M.G., F.R.S. Published by authority. Sydney, 1903. 66 + 139 pp. and 7 maps. 8vo.

The work of systematically collecting rain records in New South Wales was commenced in 1870, at which time there were only 5 records. During the 30

years that have elapsed the number of records has increased to 1703, and these are distributed over the whole of the State.

The distribution of rain during 1900 makes it convenient to divide the State into three parts — first, by a line from Mungindi, through Walgett, Nyngan, Deniliquin, and Moama, cutting off the Western Division ; and, secondly, dividing the Eastern Division into two by a line from Nyngan to Newcastle— the northern district and the southern district. The rainfall for 1900 in the Western Division is still 26 per cent below the average of all years, although the rainfall averaged 1·73 ins. more there than in 1899. In the northern part of the Eastern Division the rainfall amounted to 17 per cent below the average for all years, and the rainfall for 1900 was 6·48 ins. less than it was in 1899. In the third section the year has been more profitable ; the rainfall amounted to 16 per cent above the average of all years, and hence the rainfall in this district for 1900 was 3·85 ins. higher than it was in 1899.

Rules for Rainfall Observers. Revised by HUGH ROBERT MILL, D.Sc., LL.D. Published by the British Rainfall Organisation. London, 1904. 8 pp. 8vo.

This contains a brief account of the British Rainfall Organisation which was founded by the late Mr. G. J. Symons, F.R.S., and also the revised "Rules for Securing Uniformity in Recording Rainfall."

The Meteorological Report for the year 1901. The Survey Department, Public Works Ministry, Cairo. Cairo, 1903. 190 pp. and 26 pl.

This volume contains the Report of the Superintendent of the Abbassia Observatory, and the hourly meteorological, also the magnetic and seismological observations, made at that Observatory. By arrangement with the Sudan Government, the meteorological observations taken at various stations in the Sudan are published in this volume. The ten year means 1891-1900 at Wadi Halfa are also given.

The Cloud World : Its Features and Significance. Being a Popular Account of Forms and Phenomena, with an extended Glossary. By SAMUEL BARBER. London, 1903. 8vo. 139 pp.

The author states that this is not a formal treatise upon the branch of meteorology of which it treats, but a record of personal observations with a view of forecasting weather and developing a delightful field of Nature-Study. In the earlier portion of the work, the author has adopted a method of analysis, not much applied hitherto, defining the various features of cloud-formation, *e.g.* line, volume, colour, and the like ; and this with a view to stimulate observation and inquiry into the physical conditions of their attendant phenomena. The book includes numerous illustrations of cloud forms.

Veröffentlichungen des Meteorologischen Observatoriums Aachen. Ergebnisse der Beobachtungen am Observatorium und dessen Nebenstationen im Jahre, 1902. Jahrgang viii. Karlsruhe, 1903. 87 pp. and pl. 4to.

In addition to the usual report and tables, this volume contains the following papers :—"Das Klima von Aachen, ix. Teil ; Ergebnisse der Niederschlags-Registrierungen" : von Dr. P. Polis (14 pp.).—"Die Gewitterböe in der Rheinprovinz am 26. Juli 1902" : von Dr. P. Polis (16 pp.).—"Die Beziehungen zwischen meteorologischen und seismologischen Vorgängen" : von A. Sieberg (5 pp.).—"Über Föhnwirkungen im Hohen Venn und der Eifel" (2 pp.).

Weather Folk-Lore and Local Weather Signs. Prepared by EDWARD B. GARRIOTT, Professor of Meteorology. Bulletin No. 33. W.B. No. 294. U.S. Department of Agriculture. Weather Bureau. 153 pp. and 21 charts. 8vo. Washington, 1903.

The object of the author has been to separate from the mass of available data the true sayings that are applicable to the United States, and to combine the material thus collected with reports on local weather signs, which have been specially prepared by observers of the U.S. Weather Bureau.

It is pointed out that the laws that govern the distribution of the earth's atmosphere and control its phenomena necessarily produce different results on different parts of the earth's surface. It is also shown that wind directions, as influenced by areas of high and low barometric pressure, produce high and low temperatures, fair and foul weather, and that all true popular weather sayings of ancient origin have been coined from the utterances, born of experience, of men who have observed, without understanding the causes thereof, the first indication of approaching weather changes. The author quotes and discusses references and sayings relating to wind, clouds, barometer, unseasonable weather due to abnormal barometric conditions; the physical effect on animal life of changes in atmospheric pressure, temperature, humidity; animals, birds, fish, insects, plants, sun, moon, and stars.

A summary, illustrated by 21 charts, is given of local weather signs as observed at 143 regular stations of the U.S. Weather Bureau.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

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WATER-VAPOUR.

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[A Lecture delivered before the Royal Meteorological Society, March 16, 1904.]

THE aim of the Council of this Society in arranging the series of Lectures, of which they have done me the honour of requesting me to deliver one to-night, is to create, or perhaps to deepen, amongst those who are as yet non-meteorologists, an interest in the study of Weather, and of the atmospheric conditions which that word may be taken to connote; and this aim they seek to achieve by dealing in a popular manner with some of the more familiar phenomena of meteorological science.

The subject which I have chosen for my Lecture is one of the greatest importance to the meteorologist, because in one way or another it enters into nearly every problem with which he has to deal. I do not propose, however, to follow it into any of the more complicated processes of the atmosphere, but in as clear and simple a manner as I can to show what Water-Vapour is, and to explain some of the properties it possesses; and then to say a little respecting the part it plays in connection with some meteorological phenomena with which everybody is to some extent acquainted.

In beginning my task, however, I must at the outset ask for the indulgence of that portion of my audience—Fellows of the Society and others—whose knowledge of my subject is at least as great as my own, and to whom most of what I shall say will necessarily be very familiar and elementary. I trust they will bear with me for the sake of others whose acquaintance with scientific matters is less extensive, and for whom, as I have said, these Lectures are primarily designed.

First of all then let me explain what vapour is:

Vapour and *gas* are words which mean essentially the same thing. Every gas is probably the vapour of some liquid or of a solid; and as most of you doubtless know, nearly every gas can be reduced to the liquid or to

the solid state. Quite recently this has been done in the case of air and of other so-called "permanent" gases, and liquid air and liquid hydrogen have now become substances of comparatively common laboratory use.

But the word "*vapour*" is conventionally used to indicate the gaseous condition of bodies which we are ordinarily acquainted with only as liquids or solids; whilst the word "*gas*" is reserved for other bodies which are not generally found in any other than the gaseous state. To-night I am to deal particularly with the vapour of water, or with water in the state of a gas.

If you were to fill a saucer with water, and were to leave it exposed to the air, the water would gradually disappear, and presently the saucer would be left dry. If you were to fill a second saucer with another fluid, say ether, and were to expose it under the same conditions as the first, the same thing would happen, only in this case the ether would disappear far more quickly than the water had done. Indeed, so volatile is ether that if a few drops of it were allowed to fall upon this table they would become invisible almost instantaneously.

But what has become of these bodies when they have thus disappeared after having been exposed to the atmosphere? Of course they have not ceased to exist; but they have changed the state of their existence, and they have passed from the liquid state, in which we could see them and handle them, into the gaseous state in which they have become an invisible, impalpable vapour. The process by which this change of state is brought about is known as evaporation.

From what I have said respecting water and ether you will have gathered that this change of state occurs far more readily with some substances than it does with others. Had we exposed in a third saucer another body, alcohol, we should have found it to have an intermediate rate of evaporation, and that whilst it evaporated more rapidly than water, it did so less quickly than the ether; and probably no two substances evaporate at exactly the same rate. In every case, however, we can accelerate the process by applying heat to the fluid or the solid which is being evaporated.

Every one knows that the readiest way of drying wet clothes is to place them before the fire. But when we do so, we simply avail ourselves of this property of heat to hasten the process of evaporation, or in other words to transform into vapour the water which is held suspended in the pores of the cloth.

Evaporation is not, however, limited to bodies which are comparatively warm. As a matter of fact it goes on over a very wide range of temperature, and in the case of water, with which we are now chiefly concerned, it does not cease even when the water passes into the solid state and becomes ice. As the ice becomes colder the rate of the evaporation decreases, and there is probably a point at which it ceases altogether—at any rate with very low temperatures it becomes so extremely slight that it is very difficult to detect it. But nevertheless in nature a good deal of evaporation actually takes place from ice, and in considering the sources from which the supply of vapour in the atmosphere is drawn, that fact has to be kept in mind.

But there is another very important phenomenon involved in the process of evaporation, to which I must direct your attention. If you

will place a drop of ether upon the tip of your finger the ether will at once evaporate and disappear. But as it disappears you will be conscious of the disappearance of something else also, namely of a certain amount of heat which will have been extracted from your finger, leaving behind it an unmistakable sensation of cold.

Now when water evaporates the same thing occurs,—a large quantity of heat always becomes absorbed in the process,—and people take advantage of the fact, especially in warm climates, for the purpose of cooling other bodies.

A homely illustration of this, which at least the ladies in my audience will appreciate, is afforded by the domestic "butter-cooler," which is a covered vessel made of porous, unglazed clay, readily able to absorb moisture. The "cooler" is supplied with water so that its sides and top may be kept constantly wet, and it is then placed in a current of air. The process of evaporation then begins, and heat is in consequence taken from the "cooler," and from whatever may have been placed beneath it, and the more quickly the evaporation proceeds the greater will be the resulting reduction of temperature. In a brisk, hot, dry wind, causing a very rapid evaporation, the temperature of the contents of the "cooler" may become reduced in this way by as much as 30° or 40°.

The loss of heat by evaporation may be shown by the simple instrument known as a cryophorus, or "ice-carrier." It consists of a bent glass tube having a bulb at either end, and containing nothing but water and water-vapour, all the air in it having been expelled when it was made. The water having been gathered in the larger bulb, the smaller bulb was immersed in this mixture of ice and salt. The vapour in that bulb became quickly condensed by the cold, and a rapid evaporation of the water in the other bulb was produced in consequence; and although that bulb is, as you see, freely exposed to the warm air of the room, the loss of heat sustained by the water it contains has been such that it has become covered with quite a considerable thickness of ice.

But let us try to get some idea of the amount of heat required for the process of evaporation. If we were to place a kettle filled with ice-cold water upon a fire and cause it to boil we should raise the temperature of the water 180°—that is from 32° to 212°. Suppose it took ten minutes for this to occur. Now, if the kettle were allowed to remain upon the fire, we should find that there would be no further rise in the temperature of the water, which would remain at 212°. But all the while heat would be passing into the water from the fire at the same rate as before, and the water would be rapidly evaporating and passing away into the atmosphere as vapour; and if we were to keep the fire at just the same intensity all the way through the experiment, we should find that it would take rather more than 53 minutes for all the water to disappear. This will give us some idea of the large amount of heat which becomes used up in the evaporation of water.

We may state this fact in another way: the quantity of heat required to evaporate one pound of water at the temperature of 212°, would be sufficient to raise the temperature of 5·36 pounds of water from the freezing to the boiling point.

Now the question arises, what has become of all this heat?

The old idea, based upon the theory that heat was itself a form of

matter distributed amongst the atoms of bodies, was that it had become dispersed and hidden away amongst the atoms of vapour,—stored up in them,—and therefore it was called *latent* heat. To-day, with another conception of what heat is, we think of it rather differently, and regard the heat as having been used up in doing the work required to change the water from the fluid into the gaseous state; in pulling apart the molecules of water and setting them free as atoms of gas. But notwithstanding this modification of our views as to the nature of heat, we still speak of the heat consumed in the process of evaporation as the "*latent* heat of evaporisation."

The precise amount of heat which is thus required to do the work involved in the evaporation of a given mass of water, will of course depend upon the temperature at which the evaporation takes place; but when later on the vapour becomes condensed and the molecules reunite, exactly the same amount of heat as became latent will be yielded up and restored again to the atmosphere.

Now, as these processes of evaporation and condensation are constantly going on in Nature upon a very large scale, it is obvious that they must withdraw from, and return to, the atmosphere large amounts of heat, sufficient to affect very appreciably its temperature; and indeed they are in this way active agents in the production of some important meteorological phenomena, as I hope presently to be able to show.

Now I pass on to notice a property of vapour which also has an important application to meteorology.

When bodies are in the solid state their molecules adhere so closely that it requires a considerable amount of force to overcome their attraction for each other. In the fluid state their mutual attraction is considerably lessened, and the particles will readily glide over one another, although here also a good deal of force is required to widen the distance between them. But when a body passes into the gaseous state this attraction of the particles for each other ceases; they no longer cohere, but on the contrary the atoms now fly apart from each other, and we may imagine them as shooting out in every direction, and striking against any obstacle that may happen to be in their paths.

This power of indefinite expansion is indeed the characteristic property of all gases, and water-vapour being a gas it is a property of water-vapour also.

The result of applying heat to a body, whether it be in the solid, the liquid, or the gaseous state, is to lessen the cohesion of its particles; and if the body be a gas the tendency of the particles to fly apart will be greatly increased. This may be illustrated by a simple experiment. Here is a flask which contains only air, and which is connected by a bent tube with the bottom of an upright glass tube the top of which is closed. This upright tube is filled with a coloured fluid, and its open end is immersed in a dish half filled with the same fluid. By applying heat to the flask the air within it is caused to expand and to pass from the flask to the upright tube, up which it rises in a series of bubbles, with the result that the fluid is gradually driven down out of the tube into the dish.

If a small quantity of vapour were to be introduced into a glass globe from which all the air had previously been withdrawn, the vapour would

immediately expand, the atoms of which it is composed would rush apart from each other with great rapidity, and almost instantly they would quite fill the globe. It would be easy to show that when this had taken place a certain amount of pressure, or push, would be exerted upon the sides of the globe, by the atoms of gas which those sides prevented from spreading themselves out still more. If now a further supply of vapour were to be added to that already in the globe, the process would be repeated; the atoms would spread themselves out as before, and would mingle with those already there; but their number being now greater, whilst the space in which they were confined remained the same, the pressure they would exert upon the sides of the globe would obviously be increased.

But this process would not go on indefinitely. If the supply of vapour were constantly added to, a point would presently be reached at which we should find, if we had the means of measuring it, that the pressure upon the interior of the globe ceased to increase, but instead we should find that a deposit of water was beginning to take place upon its sides. In fact the process of *condensation* would have commenced, and any additional vapour now supplied to the globe would return to the liquid state as water.

From this fact we learn that there is a limit to the amount—the weight—of vapour which can be contained within a given space; and when that limit has been reached the vapour is said to be *saturated.*

Of course it would have been just the same thing if instead of adding to the quantity of vapour in the globe we were to experiment with a given amount of vapour, and to reduce the size of the vessel which held it. As the capacity of the vessel became reduced the pressure which the vapour would exert upon its sides would increase, until presently the same critical point of maximum pressure and maximum density would be reached as before, and again the vapour would have become saturated. Any further reduction in the capacity of the vessel would not produce a corresponding increase of pressure, but condensation of the vapour into fluid water.

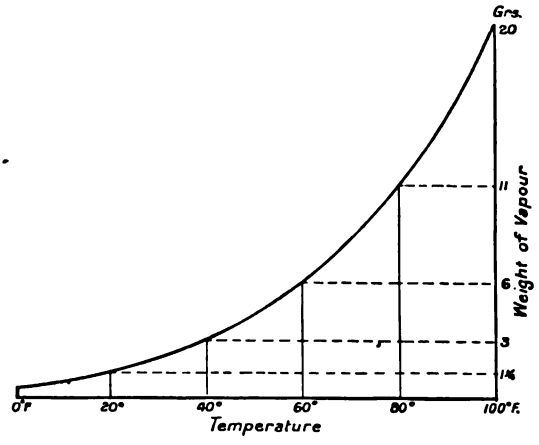
But up to this point I have supposed that the temperature of the vapour in the globe remained unchanged. Suppose, however, that when the point of saturation was reached we were to supply heat to the globe so as to warm the vapour within it. The conditions would now become somewhat altered. First of all the vapour would expand, and the pressure it would exert upon the sides of the vessel would in consequence be increased; but at the same time we should find the process of condensation, if it had begun, would be arrested, and the particles of water already deposited would again become transformed into vapour. Indeed we might now add to the supply of vapour, and in that way further increase the pressure until another definite point had been reached, which would be that of saturation corresponding to the higher temperature of the vapour, when the process of condensation would recommence. And this process of adding to the maximum pressure and maximum density of the vapour by simply increasing its temperature might, in theory at least, be continued indefinitely.

Here then is another fact of importance to the meteorologist which I may restate concisely thus: the weight of water-vapour which a given

space can contain depends directly upon the temperature of the vapour.

Let us suppose that the temperature of the vapour is that at which ice melts, 32°; the maximum amount of vapour at that temperature which a vessel of 2 cubic feet area could contain would weigh about 4¼ grains. If, however, its temperature were that of the air on an ordinary summer day, say 60°, the same vessel could contain as much as 11½ grains of vapour; and if the temperature were to be raised still further to that of a hot summer afternoon, say 80°, 22 grains of vapour might be squeezed into the same vessel without any deposit of water taking place, or in other words before saturation was reached.

This will be made clear by the following diagram, which shows graphically how the maximum density of aqueous vapour increases with temperature. The bottom of the diagram is divided into equal spaces representing equal increments of temperature from 0° to 100°. The



length of the vertical line at each point is proportional to the amount of vapour required to saturate a given space at the temperature indicated; and the curve which joins their extremities is the curve of vapour density as it is affected by temperature. The figures at the side of the diagram show the weight in grains of a cubic foot of vapour under the pressure of 30 inches of mercury.

You will remember that when I first mentioned the glass globe for holding the vapour I supposed it to have been completely exhausted of air before the vapour was admitted to it, and therefore up to this point we have been dealing with a vessel containing vapour of water and nothing else.

But, save in one respect, the result would have been precisely the same as that I have described if at the time when the vapour was admitted the globe had been filled with dry air. The vapour would still have diffused itself throughout the globe in the same way as before, but since it would now have had to overcome a certain amount of resistance from the air, through which it would necessarily have to push its way, it would no doubt take a little more time in doing so.

But the *amount* of vapour which the globe could hold before becoming

saturated would be just the same, and the pressure which the vapour would exert upon the sides of the globe would also be exactly the same as when the globe contained vapour alone. The only difference from the previous state of things would lie in the total—the *actual*—pressure which the sides of the globe would now have to sustain; because the air would of itself, and quite independently of the vapour, be now exerting a pressure of its own upon them. So that as a matter of fact each gas—the air and the vapour—would now be exerting its own pressure, and exactly the same *amount* of pressure, as if the other were absent; and therefore the total push upon the sides of the globe would now be the sum of that due to the air *plus* that due to the vapour.

These last two facts relating to the action of vapour when mixed with air were discovered by Dr. Dalton, and they are generally stated in the following way, and are known as Dalton's laws:

(1) "The mass of vapour which can be contained in a given space is the same whether this space be empty or filled with gas; and

(2) "When a gas is saturated with vapour the actual pressure of the mixture is the sum of the pressure due to the gas and vapour separately; that is to say it is equal to the pressure which the gas would exert if it alone occupied the whole space, *plus* the maximum pressure of vapour for the temperature of the mixture."

So far then we have seen that vapour is capable of exerting pressure; that when its pressure exceeds a certain point, dependent upon its temperature, the vapour will condense again into water; and that both these results occur quite irrespective of whether the vapour is mixed with air or not.

I have already said the tendency to expand and to occupy more space is a characteristic property of all gases; but on the other hand gases are easily compressed, and readily accommodate themselves to a more limited space when they are subjected to pressure. If you were to attempt to compress a piece of some solid substance, lead for example, into a smaller space,—to bring its molecules into closer permanent touch with each other, you would need to exert a tremendous amount of force to succeed. Similarly if you were to try to compress into smaller compass a mass of fluid water, soft and non-resisting though it might feel to your touch, you would find it a very difficult feat to achieve; but with a gas it can be done quite easily.

In speaking just now of the formation of vapour, I said that the loss of heat which that process involved was due to the *work* which had to be done upon the molecules of water in pulling them apart. But it is only by doing work upon a gas that you can compress it into a smaller space and bring its atoms into closer contact; and whenever work is done it leaves behind it an effect of heat equivalent to the amount of work which has been expended. Every cyclist will readily endorse this statement, because whenever he refills the deflated tyres of his machine he has to do some amount of work in compressing the air by means of his pump, and he knows that one result of his work is to make the barrel of his pump *warm*. In this way he proves by actual experiment that the mechanical energy he exerts is converted into heat sufficient in amount to be readily appreciated by his sense of touch.

Now suppose that after the cyclist had perfectly filled his tyres, one of them should burst and the enclosed air were suddenly to escape. In doing so the escaping air will now have to perform work in making room for itself in the atmosphere outside, and the result will be that it will become chilled, because the heat stored in the air pent up in the tyre, or some of it, will become used up in overcoming the resistance the escaping stream of air will meet with. And further, if we were at liberty to suppose that none of the heat developed in the pumping had been allowed to escape through the tyres, that amount of heat would be exactly what would be required to accomplish the work to be performed in bringing the air back to the temperature, and to the volume, it had before the pumping began. If, however, the temperature of the air enclosed in the tyre had fallen to that of the surrounding atmosphere, the escaping air would still have had to draw upon the heat it possessed for the accomplishment of the work to be done; and the result would then be that the escaping stream would become chilled below the temperature of the outside air, and so much chilled that if your hand could be held in the path of the stream you would feel a distinct sensation of cold.

This cooling of air by causing it to suddenly expand is turned to practical account nowadays for bringing meat to this country from the Antipodes, the meat being kept in a frozen state throughout its long journey across the hot regions of the tropics.

But in nature this *dynamical* heating and cooling of air, and of the water-vapour in the air, is constantly going on. From various causes portions of the atmosphere are always being subjected to an increase of pressure in one place, whilst other portions are being relieved of pressure elsewhere; and to the changes in its temperature which result from these changes of pressure, many most important meteorological phenomena are directly due.

But I want you to notice that these changes of temperature are purely mechanical results, due to the work done by the air itself against its surroundings; and that they are not due to heat having been communicated from or to some outside source or body, as for instance from the direct action of the sun's rays in the one case, or by the radiation of heat into space in the other. When air or vapour rises to higher levels of the atmosphere it becomes subject to a decreased pressure, because the amount, and therefore the weight, of the air above it becomes so much less. When, on the other hand, it descends nearer to the earth, the superincumbent pressure becomes increased from the opposite cause, since there is then a greater mass of air resting upon it than before, and compressing it into smaller compass. In the one case there is expansion, leading to a cooling of the air; and in the other compression, and a rise of temperature. The normal rate of change of temperature due to these causes is called the *adiabatic* change of temperature—a useful word which means literally "without passage across," and is used by meteorologists to signify that the change of temperature has been produced without heat having been taken from or supplied to the air from outside sources, but has in fact resulted simply from the work which the air has itself done.

The rate of this adiabatic change of temperature in dry air is 1·6°F. for every 300 feet, or 1·0°C. for every 100 metres of height.

Before leaving this part of my subject, I should like to show you two experiments to demonstrate the mechanical cooling and heating of air of which I have been speaking.

The first experiment will show not only that air becomes cooled by expansion and heated by compression, but it will also enable us to see one effect of these changes of temperature upon air somewhat fully charged with water-vapour.

Here is a large glass globe placed with its mouth downwards. The mouth is, however, securely stoppered, although at will the air of the room can be given free access to the inside through this glass tube, which passes through the cork and rises above the centre of the globe. By means of another but shorter tube water can be made to flow into the globe from this jar. By raising the jar sufficiently high the water enters the globe by gravity; and the air tube being open, the air which becomes displaced by the water passes out into the room. When the globe is sufficiently filled with water the air tube is closed, and the jar being then lowered the water readily flows back again into it. But now the air previously expelled cannot get back again into the globe from outside, and therefore that which was left in the globe expands to fill up the space occupied by the retreating water. In expanding, the air becomes cooled below the "dew-point," or the temperature at which the vapour becomes saturated, and therefore condensation takes place, with the result that a *cloud* is formed by the minute particles of water,—"water dust"—which are left suspended in the air, and which are made readily visible by passing a beam of light through the globe. When the jar is again raised, the water re-enters the globe, and the space available for the air now becomes contracted; the air is in consequence compressed, and at the same time its temperature rises above the dew-point with the result that the cloud disappears.

The next experiment is introduced to show in another way the same dynamical cooling of air by expansion, but followed in this instance by an increase of pressure due to the absorption by the air of heat from an external source.

Here is a globe similar to that just used, but differently arranged. The mouth of the globe, which is now placed uppermost, is again closed airtight; but by means of a pump air can be forced into the globe so as to considerably increase the pressure inside, and by means of this water-gauge the amount of the compression can be readily observed. First, air is pumped into the globe until the water has sunk nearly to the bottom of the left leg of the gauge, and risen nearly to the top of the right leg. Then by opening a valve the compressed air is allowed suddenly to escape, and at once the water-gauge shows that the pressure inside and outside the globe has become equalised. But by its sudden expansion the air which was compressed in the globe has become colder than the external air, as will be made apparent by what is about to happen. As soon as the valve had been opened I closed it again, so that air could no longer pass into or out of the globe. But heat can pass through the sides of the globe, and as a matter of fact it does so pass, and the temperature of the inside air is now steadily rising. As the air becomes warmer it seeks to expand, but being restrained by the sides of the globe it is each moment exerting a stronger push upon them, and upon the water

in the gauge, which fact is demonstrated by the gradual sinking again of the water in the left leg of the gauge and its rising in the other, as it did just now—of course to a greater degree—when the pressure was increased by the use of the air pump.

Having said so much respecting water-vapour itself, let me now say a little respecting the part it plays in the science of Meteorology. And the first thing I ask you to note is that this vapour is always present in the atmosphere. I don't know whether my experience has been peculiar, but I have more than once been surprised to meet with reasonably well-informed people who did not appear to have realised that fact.

The late Mr. Henry Blanford, F.R.S., told a tale respecting a gentleman who was sitting one hot damp evening during the rainy season in a room in Calcutta. On the table before him was a glass of iced brandy and water, and on lifting it he was surprised to find that not only was the glass itself wet on the outside but quite a little pool of water had formed around it upon the table. At first he thought the tumbler was cracked, but on collecting some of the moisture from its sides and putting it to his tongue he found it to be tasteless. "Very odd," he said, "the *water* comes through the glass but the *brandy* doesn't." Of course he had merely demonstrated the existence of water-vapour in the atmosphere of the room in which he sat, and by a slight modification of his apparatus we may repeat his experiment.

Here is a tin box the sides of which have been painted black. By putting inside it a freezing mixture of pounded ice and salt its sides have become greatly chilled, and reduced to a temperature below the freezing point of water. The warm air of this room which has come into contact with the cold box has in its turn become chilled to a temperature much below its dew-point, and being unable to any longer support the amount of vapour it contained, it has deposited the surplus upon the box, where we can see it frozen as a white rime or hoar-frost.

The quantity of vapour present in the atmosphere varies very much in different regions of the globe, and in most places it also varies a great deal at different times, and occasionally within very brief periods.

Vapour is a most important factor in climate, a word which sums up the combined effect of many varied atmospheric conditions. There are parts of the globe where vapour is always present in great abundance, and in such places the air is constantly damp, and in a nearly saturated condition. The calm oceanic region near the equator, which marks the meeting-place of the North-east and South-east trade winds, is an example of such a humid climate.

On the other hand there are regions where the quantity of vapour is always small, both relatively and absolutely. Inland regions far removed from any considerable source of supply, and subject to strong sun-heat, are generally in this condition; and the central portions of the Australian continent, parts of Arabia, and the desert regions of Africa, are examples of such parched and arid climates.

The amount of vapour in the air has a great deal to do with our personal comfort. A dry cold air is less unpleasant, and never feels so cold, as a cold damp air; and that even when the temperature of the

damp air, as shown by the thermometer, may be actually higher than that of the drier air. But our sensations are often at variance with the thermometer, and more often than not they are so because of the way in which they are affected by the vapour in the air. In dry air a degree of heat also can be enjoyed which with a humid atmosphere would be simply unendurable.

Vapour absorbs heat more readily than dry air does, and, in the case of the cold damp air, our bodies are robbed of their heat by the vapour at a time when heat can ill be spared; in the opposite case of a high temperature the dry air, thirsty for moisture, induces a rapid evaporation from our bodies, and by taking from them the heat required for the process, in the way we have already seen, this keeps them relatively cool. The damp air, on the other hand, already charged with moisture, checks evaporation, and if it be hot as well as damp the temperature of the body rises.

This probably explains why in certain hot but *dry* regions men can work out of doors without discomfort in temperatures much higher than would suffice to make sunstroke or heatstroke almost certain elsewhere where the climate is less hot but more humid. Sunstroke is far less frequent in the hotter but drier interior of the United States than it is on the eastern seaboard States where the air contains much more vapour; and even here in England there are occupations in which the workmen have to do hard work, such as in unpacking the ovens in which pottery has been baked, soon after the oven has been opened, in temperatures which they could not endure but for the fact that the air is not only hot but very dry also.

Every part of the globe yields its contribution to the vapour supply of the atmosphere—land surfaces, lakes, rivers, all contribute their quota; but by far the largest amount is drawn from the ocean, and especially from that part of the ocean upon which beats a hot tropical sun. Most of the rain which falls upon the land in summer is probably returned again to the air in the form of vapour, and it is obvious that the total amount of vapour contained in the atmosphere must be enormous.

Guesses have been made as to the relative proportions of dry air and vapour which together form our atmosphere, but they are guesses merely. To get some data upon which a more definite estimate can be based evaporation gauges are employed, and from them we get useful information, although its value is somewhat limited because of the artificial conditions under which the gauges sometimes work, and also because it is not always safe to apply the data they yield for a particular district to a large area presenting a great variety of physical features. In the wettest parts of the British Isles much more rain falls than is evaporated, and probably in the driest parts rainfall and evaporation about balance each other in the summer half of the year, whilst most of the water required to supply the springs and underground waters comes from the unevaporated portion of the winter falls. In India it was found that the loss of water by evaporation from a large tank constructed to supply the city of Nagpur was two and a half times more than the amount actually used in the city, a fact which shows what a very practical bearing this aspect of our subject has in relation to some important problems of everyday life.

Water-vapour is, bulk for bulk, much lighter than air, and a cubic foot of it, at the temperature of 60° and the pressure of 30 inches of mercury, weighs only 5¾ grains, whilst a cubic foot of dry air under similar conditions of temperature and pressure weighs 536 grains. Owing to this lighter specific gravity, vapour readily diffuses itself throughout the atmosphere when it passes into it; but its diffusion by gravitation alone would be a very slow and imperfect process, for if the air was always quite still the lower layers of the atmosphere would in some regions become saturated, and by remaining so would prevent further evaporation from taking place, whilst elsewhere the absence of vapour-laden winds would involve a perpetual drought. But the winds and the general circulation of the air are far more powerful agents than gravitation in transferring the vapour quickly from one part of the globe to another, and in effecting its fairly equal distribution over its entire surface.

The amount of vapour in the air at any particular spot is ascertained by means of an instrument known as a *hygrometer*. There are many substances which are readily affected by moisture, and some of them are used in some forms of the instrument; but generally these *hygroscopic* bodies, as they are termed, are more useful for indicating the *relative* dampness of the air. Catgut is so employed in the old-fashioned Dutch toy house, from which a woman emerged if the air was dry and the day promised to be fine, whilst if the air was damp a man armed with an umbrella came out by the other door. A strip of seaweed is another substance I have often seen used for the same purpose, the salt upon it absorbing the vapour and becoming damp as the moisture of the air increased. But I have seen both these *hygroscopes* gravely consulted when they have been exposed indoors in a kitchen where a large fire was kept burning!

But the hygrometer is used to give us more reliable information as to the amount of vapour in the air.

In Saussure's hygrometer the extension or contraction of a human hair is used to move an index upon a scale; and in other forms of hygrometer a similar effect is obtained by the untwisting of a small bundle of hairs, by which a small index is turned.

Regnault's hygrometer consists of two polished silver tubes to which are attached glass tubes. In one of these is a thermometer intended to give the temperature of the air; the other contains ether in which is inserted the bulb of a second thermometer, and also a glass tube whose upper end is open to the air. There is a communication between this silver tube and an aspirator, by means of which the air is drawn through the ether; this causes a constant bubbling and evaporation of the ether, with a corresponding fall of temperature, and presently a dew is formed upon the silver tube. At the moment when this occurs the two thermometers are read, and from the difference between their readings the required information respecting the vapour can be obtained.

Daniell's hygrometer has two glass bulbs connected with each other. One contains ether and a thermometer as in Regnault's, the other only vapour of ether. The outside of the latter bulb is covered with muslin which is damped with ether so as to chill it by evaporation. This condenses the vapour inside and produces a rapid evaporation from the other bulb, with a fall of temperature, and a deposit of dew upon

its outside; and when this occurs the thermometer inside is read together with another outside, as in the case of Regnault's instrument.

In Dines' hygrometer a similar result is produced in a simpler way, and cold water may be employed to chill the plate of blackened glass upon which the deposit of dew is formed.

But the instrument which is now almost universally employed is Mason's hygrometer,—generally known as the dry and wet bulb hygrometer. Two similar thermometers are exposed to the air side by side, but the bulb of one of them is covered with thin muslin which is kept constantly moist, whilst the other remains dry. By the evaporation which takes place from the damped muslin, the temperature of that bulb becomes reduced, and if the air be very dry the difference between its reading and that of the dry thermometer will be very considerable, —under certain conditions, in hot climates it may exceed 20°; but if the air be saturated with vapour no evaporation can take place, and the two thermometers will then read alike. The difference between the two readings indicates therefore the relative dryness of the air, and from the amount of difference and the actual temperature we can readily obtain, by means of special tables, what we require to know of the hygrometric state of the air; and because of its extreme simplicity this form of hygrometer has for general use now superseded every other.

It is now time for me to say a few words respecting some phenomena of the atmosphere in which water-vapour plays a leading part. We have already seen the vapour present in the atmosphere of this room made visible to us in the form of hoar frost upon the chilled sides of a metal box. But in nature precisely the same process occurs, and on a very grand scale. When winter holds everything in its chilly grip, and grass and trees and other objects out of doors become icily-cold, they condense the vapour out of the light airs which at such times just breathe across them, and crystallize it into a mass of ice spiculæ which cling to every twig and frond, and outlines even the delicate spider's web suspended between them. Indeed nature is never more beautiful than when "Jack Frost" thus spreads his spotless veil around her, and clothes the bare branches of the trees with a feathery robe of sparkling crystals. On calm clear nights in summer, also, a similar agency is generally at work. Then the air which lies nearest to the ground becomes chilled by contact with the soil, which has itself become cooled by radiating its heat into space, and again the vapour becomes deposited, not now, however, as frost, but as dew.

When this kind of chilling of the lower air continues for a considerable time, or when it occurs somewhat rapidly over a large area, the vapour may become condensed to a considerable height, the molecules of condensed water remaining suspended in the air and forming a cold damp fog. Such a fog may be only a few feet thick or it may extend upwards for some hundreds of feet. I have seen one, covering a large level area, so shallow that the upper half of the body of a man walking through it was quite clear of the fog although his legs were invisible from a distance of a few yards. Fogs often form in valleys, the cooled air gravitating down the sides of the hills surrounding the lower levels, where the air is usually most damp, and, by chilling the vapour, filling the

bottom of the valley with a cold damp mist whilst the tops of the surrounding hills may all the time be bathed in bright warm sunshine.

A *fog* thus formed is essentially a *cloud*. The difference between a fog and a cloud may be defined very simply thus: "A fog is a cloud seen from within, whilst a cloud is a fog seen from without." When, however, the cloud is formed at very low temperatures, instead of its being composed of particles of water it consists of extremely minute spiculæ of ice, and although such clouds are usually formed at such great heights that direct observation of their composition is not possible, yet we know they must be so constituted, partly because of the low temperatures which exist in those regions, but also because of the effect such clouds produce upon the light which passes through them. When a cloud is composed of tiny round drops of water—"water-dust"—they reflect the light which falls upon them equally in every direction. But this the particles of which these lofty clouds are composed do not do, and the *halos*, or rings of light, which are formed when the light of the sun or of the moon passes through them, is just what we should expect to see if the light was reflected and refracted by minute crystals of ice. These halos are sometimes finely coloured and very brilliant.

Now, how is the chilling of the air which is necessary to condense the vapour and produce a cloud brought about? Well, it may be caused in any one of two or three ways. When a current of relatively warm air comes into contact with cold surfaces of land, such as a mountain range, a cloud is often formed by the cooling of the air which results from the contact. The mixing of two bodies of air of different temperatures may produce a similar effect; and very probably some of the thin layers of cloud, so often seen presenting a twisted and torn appearance, are formed where the faces of two superposed currents of air come into contact with each other and become to some extent intermingled.

But by far the most common cause of the formation of cloud is the mechanical cooling of vapour due to ascending currents in the atmosphere. We have seen already how this occurs owing to the expansion of the air from the reduction of the pressure upon it, and therefore I need now only point out that such ascensional currents may be caused in two or three ways. The warming of the air in the day-time by the heat radiated into it from the heated ground is one great cause of their formation. The absorption of the sun's direct heat by the vapour itself is another; and in this connection it is important to remember that vapour absorbs such heat far more readily than dry air does, and that whilst dry air is almost perfectly diathermanous—or transparent to heat—water-vapour is not. A third cause is the forcing upwards of an advancing stream of air when it encounters a sufficiently large obstacle to its onward progress, such as a range of high hills or mountains.

I daresay many of you have watched on a fairly warm day in summer the process of cloud-making due to ascending air. At first one may see some small, detached, curly clouds, which if watched will be seen to grow in size as the day proceeds and the temperature increases. If the ground happens to be rather damp, affording a good supply of vapour, their growth will proceed the more quickly, and by mid-day, or in the afternoon, the small clouds of the morning will be found to have grown to

great size, and very probably will be seen towering aloft in huge billowy masses of white, brilliantly illuminated by the reflected light of the sun; whilst very often a beautiful effect may be seen when from between two such masses of condensed vapour the sunshine lights up the dusty air below with long shafts of brilliant light. Later on the sun's rays become less ardent, the ground cools, and the upward stream of air becomes checked, and then ceases; the clouds now sink to a lower level, and becoming subject to an increased pressure they become warmed at the same time, and once again they dissolve into invisible vapour and disappear, leaving the evening sky cloudless once more.

The various forms and types of clouds have each their special characteristics and distinguishing names. Much use may be made of them as weather signs, not alone by judging from their forms, but also by considering the directions and rate of their movement, and by observing the changes which may be taking place in them. Meteorologists divide clouds into three principal groups, based principally upon their elevation above the earth; the highest are the *Cirrus*, which float at great altitudes, either as the thin sheet of ice spiculæ which produces the halos I have mentioned, or as those delicate wisps and cloudlets which frequently give so much beauty to our summer skies. Then at a lower level come the large billowy clouds of which I have spoken, and which are known as *Cumulus;* and yet lower down are the vast unbroken sheets of cloud to which the name of *Stratus* has been given. There are many compounds of these chief genera, but of these I need not stop to speak.

It is not always, however, that clouds disperse themselves in the way I have described. When the condensation of vapour reaches a certain stage, the cloud particles become so large that they sink earthwards, meeting and coalescing with others on their way, and gradually increasing in size, till they leave the cloud and fall as drops of rain.

Time will not allow me to deal at any length with this effect of the condensation of vapour; to do so would require an evening to itself. But I wish to show a map of the British Isles, on which is indicated the relative rainfall of different parts of the country: and I do so in order to point out the effect which is produced by the thrusting upwards of masses of warm and moist air arriving on our coasts after traversing the ocean.

You will notice that the regions of greatest rainfall are the hilly districts which these vapour-laden currents of air first meet, such as the western parts of Ireland, the hilly districts of Wales, and of Westmoreland and Cumberland, and the western Highlands of Scotland; and in each case the cause of the large precipitation is the forcing up of the air to a higher level, and the consequent chilling of the vapour it contains.

The Stye Head in Cumberland has the distinction of having the largest rainfall in our islands, the average fall being 170 inches per annum; but Seathwaite, also in Cumberland, comes very near it with an average fall in the year of 137 inches, and with occasional falls of as much as 6 inches in a single day.

India can, however, boast of having the wettest spot in the world, so far as is known, for at Cherrapunji, on the slope of the Khasia Hills, the annual fall, most of which falls in the five months of summer, averages nearly 500 inches, and sometimes amounts to as much as 600 inches. This enormous condensation is due to a similar cause to that which

operates at Seathwaite—the thrusting upwards of the air—in this case the South-west monsoon, which arrives from the Bay of Bengal laden with vapour drawn from the heated ocean surface.

Rain is measured in a rain-gauge, and there are forms of this instrument designed to record the times and rate at which it falls as well as the amount of the fall. From the records of such instruments we can ascertain what are the hours of the day at which rain falls most frequently, and the hours at which it falls most heavily—which is not exactly the same thing—and they also supply information as to unusually heavy falls of rain, which is of practical use to engineers and others.

Snow is another form in which the condensed vapour of the atmosphere is returned to the earth, but it is a form of exquisite beauty.

A snow-flake is built up of a number of minute crystals growing by the continual condensation of the vapour upon a nucleus, and always presenting a number of rays with an angle of 60° between them. The forms of the individual flakes are infinitely diversified, varying from a star of six simple rays to others in which subsidiary rays assume the most complicated forms; but there is never any departure from this six-leaved character.

If a snowflake be caught upon a piece of black cloth its beautiful crystalline form may be easily seen by the naked eye, but by using a magnifying glass the combinations and symmetry of its details will be found to be more wonderful than could have been imagined.

Hail is the last phenomenon of condensation to which I shall refer. Exactly how hail is formed is not certainly known, but for some time electricity was thought to have a great deal to do with its origin, and there is no doubt that hailstones are occasionally electrified when they fall. Electricity is, however, quite as likely to be a result as the cause of their formation. Hailstones are sometimes of great size, and their structure is often very remarkable, and somewhat difficult to explain. In the photographs before us we may distinguish this structure in the sections of the stones, showing concentric rings of clear, alternating with opaque, ice.

There are very many more phenomena of the atmosphere in which water-vapour plays a part—and oftentimes a very important part—to which I cannot now allude. But I have tried to show how a particle of water may be taken from the ocean and stored away invisible in the atmosphere above it. How that particle may travel for many miles to distant parts of the globe, and then by the action of another of nature's processes be changed back again into water, and fall once more upon the ground beneath. There it may fulfil its mission by assisting to maintain some form of life; or it may unite itself to other and similar drops till together they form a tiny stream, and this process of accretion continuing, the stream may gradually grow to the dimensions of a river which may bear our drop of water onwards till once again it finds itself a constituent part of the ocean from whence it came, possibly to repeat its pilgrimage in carrying out the part it is destined to play in the economy of Nature.

NOTE.—I beg to offer my best thanks to Dr. W. N. Shaw, F.R.S., for the great assistance he rendered me in the preparation of my experiments,

and for the loan of several pieces of apparatus required for them; also to Capt. D. Wilson-Barker, F.R.S.E., to Mr. J. Baxendell, to Mr. H. Sowerby Wallis, and to Mr. F. Gaster, for the loan of photographic lantern slides, those of evaporation gauges at Southport, lent by Mr. Baxendell, having been specially prepared for the lecture; and to Messrs. Negretti and Zambra, and to Mr. W. Marriott for the loan of hygrometers and other instruments which were exhibited; to Mr. Marriott I am further indebted for his assistance in other directions.

In addition to the experiments which have been described above, the Lecture was illustrated by a number of photographs of instruments, clouds, frost effects, snow, hail, etc. which were thrown upon the screen.

Report of the Meteorological Grant Committee. — The Committee appointed by the Treasury Minute of December 9, 1902, "to inquire and report as to the administration by the Meteorological Council of the existing Parliamentary grant, and as to whether any changes in its apportionment are desirable in the interests of meteorological science, and to make any further recommendations which may occur to them with a view to increasing the utility of that grant," have just presented their Report.

The Committee held meetings for the examination of witnesses upon twelve days, and received the evidence of twenty-two gentlemen; they also visited the offices of the Meteorological Office in Victoria Street, in order to make themselves acquainted with the general system maintained in that establishment, and the physical conditions under which the staff conduct their work.

The Committee directed their inquiry chiefly upon the following points:— (1) The constitution of the Meteorological Council; (2) Its administration of the annual grant of £15,300; (3) The utility to the public of its work in general, and of weather forecasts and storm warnings in particular; (4) A memorandum submitted by the Council setting forth their views upon the present requirements of the Office, etc.; and (5) The withdrawal of the annual payment by the Council towards the upkeep of Fort William Observatory.

Dealing with the forecast branch, the Committee observe that in order that the public should derive full advantage from the forecast service, special arrangements are necessary for the receipt and transmission of weather telegrams.

Under the head of the Observatory branch, the Committee state that their attention has been specially directed to the recent decision of the Council to discontinue the payment of the grant to the Fort William Observatory, which was established as subsidiary to the Observatory on Ben Nevis. The Committee find, in spite of conflicting evidence, "after weighing all the circumstances, that, on public and economic grounds, it would constitute a bad bargain to allow the observatories to disappear." They are aware that full accord has not always existed in the past between the Meteorological Council and the Directors of the Ben Nevis Observatory, and they are of opinion that, as a condition precedent to a continuance of the grant of £350, arrangements should be made for (1) a reorganisation of the management of these observatories, (2) a consideration of the general scientific purposes for which they might be used, (3) framing, with the assistance of meteorologists, a scheme defining the lines of investigation which should in future be undertaken at Fort William and Ben Nevis, and (4) securing to the Office the full right to publish telegraphic reports from Ben Nevis along with those from other stations.

The Committee were careful to ascertain what degree of accuracy had been attained in weather forecasts and storm warnings, and how far they might be pronounced to be of economic value to the public; and they state it cannot be

doubted that the system of storm warnings has been effective in the protection of life and property at sea, while three witnesses from different agricultural districts remote from each other estimate the proportion of accuracy in weather forecasts at from 70 to 90 per cent. In the opinion of the Committee, the economic value of weather forecasts and storm warnings amply justifies the cost of maintaining them—a value which perhaps the public would never fully recognise until they should be discontinued.

The Committee recommend that the registration of the Meteorological Office as a company under the Joint Stock Companies Acts should be cancelled, and that the company should be wound up, and the Office reconstituted as a department under the control of the Board of Agriculture and Fisheries, and that the Office be placed under the control of a man of science as Director of Meteorology, appointed after consultation with the Royal Society, but responsible to the Board of Agriculture and Fisheries, and making his annual report to that Department; and that an advisory board be appointed, consisting of the Hydrographer to the Admiralty, a representative of the Board of Agriculture and Fisheries, and one of the Board of Trade, and two members nominated by the Royal Society. The functions of this advisory board should be consultative only, the Director being responsible to the Board of Agriculture and Fisheries for administration. The Committee recommend that a second officer be appointed to act as scientific assistant to the Director, to assist him in the general management of the Office and in the discussion of such scientific problems as may arise; that the fixed Parliamentary grant of £15,300 should be transferred to the vote for the Board of Agriculture and Fisheries; and that the Post Office should make arrangements at the 27 reporting stations in the United Kingdom for the transmission of daily telegraphic reports between 7.15 and 7.30 a.m., and that storm warnings should, if practicable, have priority over all private messages at all hours.

The Committee call attention to the expediency of testing the efficacy of wireless telegraphy in providing advance news of weather in the Atlantic. Such news would incalculably strengthen the forecast and warning service, and might, they believe, be obtained regularly over an experimental period by co-operation either with the Admiralty, the Ocean Steamship Companies, or both. The Committee urge that no unnecessary delay should take place in organising this experiment. They also recommend that in future the cost of instruments supplied to His Majesty's ships be borne upon the Navy Votes, except where such instruments are intended for use in research or observation specially called for by the Director of Meteorology; and they consider that the premises now rented by the Council are neither suitable in character nor adequate in space for the present requirements of the Office, and that others should be provided wherein the staff might perform their duties under more favourable hygienic conditions, and necessary accommodation for the rapidly growing library might be secured; also that the staff in the library, the statistical branch, and the observatory branch should be augmented.

Minority reports are signed by Sir Herbert Maxwell and Sir W. Abney, with reference to Fort William and Ben Nevis Observatories; by Mr. Dewar, on the subject of the Council's superannuation scheme; and by Sir F. Hopwood and Mr. Heath expressing dissent from the majority recommendations in so far as they would necessarily involve an increase in the annual grant, and in so far as they relate to the transfer of this grant from the vote for scientific investigations to that of the Board of Agriculture and Fisheries.

ONE CAUSE OF AUTUMN MISTS.

By J. B. COHEN, Ph.D., B.Sc.

[Read April 20, 1904.]

THE formation of heavy mists on still evenings in the autumn over water or damp, low-lying ground is a common phenomenon,[1] but cannot be explained by the ordinary process whereby moist air in contact with a cold surface is cooled below the dew-point; for the mists are densest over water when the water is at a higher temperature than the air. This was pointed out by Sir H. Davy as long ago as 1819 in a paper published in the *Phil. Trans. Roy. Soc.* for that year.

The following experiments were made on Coniston Lake, Lancashire, in September 1900. Two minimum thermometers were attached horizontally to the top and bottom of a stout board, which was floated on the water. The experiment was made about midnight, when a heavy mist hung over the water, and the thermometers were floated half-way across and about half a mile from the head of the lake. The depth of water was 22 feet, and the bottom temperature 57°·2. By this arrangement of thermometers, the temperature of the surface water and of the air in contact with it was taken simultaneously. It is clear that if any cooling of the surface water occurred, the cooler water would at once sink. The following are the results of two experiments:—

	Temp. of air.	Temp of water.	Difference.
Experiment 1 . .	48°·2	60°·8	12°·6
,, 2 . .	46·4	60·8	14·4

The point which appears to have escaped attention is that the phenomenon of autumn mist is accompanied by a difference of temperature of the air, which is higher in the upper region of the atmosphere than at lower levels. The following temperatures were taken at different heights before sunrise on September 15 and 16, 1900. The thermometers which were used were etched on the stem and suspended about 3 feet from the ground without any screen.

1900.	Sept. 15.	Sept. 16.
Lake Level	47°·3	46°·4
Slope of Coniston Old Man . . . 1750 ft.	51·8	49·6
Summit of Coniston Old Man . . 2600 ft.	52·7	50·9

The temperatures at the different heights were not taken simultaneously, but within an interval of about an hour and a half necessary to ascend or descend the mountain. On the first morning the temperatures were taken on the descent, and on the second morning on the ascent, so as to counteract any change which might occur during the interval between the readings. Thus, there was a difference in the one case of 5°·4, and in the other of 4°·5, between the lake level and the summit. I was very fortunate on both mornings, especially on the first,

[1] Dr. John Dalton drew attention to this phenomenon when at Kendal, in the form of a query in the *Ladies' Magazine*, which he answered himself; but gave a very incomplete explanation. See *Life*, by Dr. Henry.

when the atmosphere was unusually still and clear on the tops. All the lower ground as far as the horizon lay immersed in a perfectly level sea of purple mist, through which the peaks of the higher hills projected, forming, as it seemed, little scattered islands which were quite clear and sharply defined. Moreover, there was scarcely any dew either on the grass or stones on the summit, whereas it lay very thick everywhere at the level of the lake.

The explanation which seems to follow from the above observations is, that after sunset in still weather the higher ground as it passes into shade begins to cool by radiation, and to cool the air in contact with it, which becomes denser and flows down to a lower level. The cold air on coming into contact with the warm moist air above the lake and surrounding ground, cools the latter below the dew-point and produces mist. The densest mist will naturally be found above damp ground or over water, which is precisely what occurs. Not only so, but if the sheet of water is long and narrow, with hills sloping down on both sides, as at Coniston, a thin column of mist will form where the stream of mist from both hillsides meets in the middle. This phenomenon is easily observed on Coniston lake by any one sitting in a boat an hour or two after sundown. At the same time a steady stream of mist may be seen flowing towards the lake from the adjacent meadows. The effect may be represented diagrammatically by dotted lines as in the following sketches.



Fig. 1.



Fig. 2.

Fig. 1 shows the descent of cold air to the lake level and formation of mist above the warm water. Fig. 2 shows the final effect when the valley has been partly filled up with mist.

As the process continues, the whole basin of the valley fills with mist, which will go on rising until only the hill-tops remain visible, giving rise to the effect seen from the summit, and already described. After the sun has risen the mist clears, and the ground is found to be covered with a heavy dew. The dew is, however, not true dew in the sense that it is not produced by the deposition of moisture rising out of the ground and condensed by contact with a cold surface; but is formed by the deposition of drops of water suspended as mist in the air. That this is

the case was easily shown by mooring a tin dish containing a freshly cut sod free from dew some distance from the shore of the lake whilst mist was forming. As the mist probably prevents radiation from the grass blades of the sod, the sod must rather gain than lose heat by contact with the water surrounding the dish, which is warmer than the air. Yet, before sunrise the following morning, the blades of grass in the dish were covered just as plentifully with dew as the grass of the surrounding meadows. If this occurs on the water, it is more than probable that a similar process takes place on the surrounding land. This deposit must therefore be differentiated from ordinary dew, and I propose for it the name of "false dew," as it is impossible to distinguish it in appearance from ordinary dew.

It is now apparent why the temperature of the air at greater elevations is higher than at the lake level. The cold air which flows into the valley displaces the warm air which rises. This process cannot be limited to any particular season, but must take place whenever the earth has been exposed to the sun, and when after sunset the sky is clear and the air still.[1] It only becomes evident in the autumn by the formation of mist. During the summer months the ground becomes more heated, and therefore retains its heat after sunset much longer than in the autumn. Consequently the cold air, as it flows downwards, is warmed more rapidly by contact with the ground than it would be later in the season, when the days are shorter and the ground becomes less heated. No precipitation of moisture therefore occurs above the lake and low-lying ground, and the phenomenon so noticeable in autumn escapes observation.

DISCUSSION.

Dr. W. N. SHAW, after reading the paper, went on to say that the careful investigation of the physical processes of meteorological phenomena was of great value. It was always possible to give plausible explanations of phenomena, which would not bear the strain of quantitative measurements. He was very glad Mr. Cohen had taken the trouble to make the observations discussed in the paper. He did not think the phenomenon investigated was confined to mountain valleys with a steep slope on either side and water at the bottom. It probably took place on clear nights whenever radiation occurred, and a cold stratum of air was formed near the ground. Just as water finds its way to a river, so cold air would make towards the bottom of the valley; and when the region of saturation was reached, the mixing of the cold air with the warmer air over the water or moist ground would result in the formation of mist. Mr. Dines was rightly of opinion that very little cloud was formed by the mixing of cold air with warmer moist air; but these observations showed one instance of the formation of cloud by mixture, and many surface fogs must be formed by a similar process. Rivers were commonly supposed to generate fog which would spread from them over the surrounding country. Fog found over rivers or near to them might be caused by the cold air of open spaces flowing

[1] The occasions on which the air at a higher level is warmer than that at a lower level are comparatively few. Miss B. C. Collingwood of Coniston was kind enough to take minimum thermometer readings daily at levels 440 feet apart, from November 1901 to the end of September 1902. The higher temperature at the higher level occurred on 9 days in April, 2 days in May, and 4 days in September. These occasions were generally associated with still atmosphere and heavy dew.

to the river courses. In hilly districts, with the continued flow of cold air, the valleys gradually get filled up with mist, although the surface flow was towards the lower level. He (Dr. Shaw) had recently been asked if a building near a river bank would act as a trap for fog and prevent its escaping from the river. He was of opinion, however, that quite the contrary would happen, and the cold air necessary to form fog would be diverted by the building from it.

With regard to the question of the formation of what Mr. Cohen called "false dew," he desired more observations as to whether, as mist was translucent, if not transparent, radiation might not still go on from the blades of grass, and true dew be formed. In a paper by Mr. J. Y. Buchanan on the "Meteorology of Ben Nevis, Clear and Foggy Weather," it was mentioned that even with a fog lasting for days, diurnal range of temperature was to be observed which might be due to radiation, although Mr. Buchanan had himself suggested the possibility of its resulting from warmer air ascending the mountain during the day and *vice versa*. Another point he would like to see investigated was the rise of temperature at the upper levels after sunset. Possibly this was part of the process of filling up the valley with fog-laden air, the bottom layer being successively colder during the process, the earlier and warmer layers being pushed gradually higher up.

Dr. H. R. MILL exhibited on the screen several lantern slides showing the physical conditions of Coniston Lake. He remarked that the phenomenon was only too familiar to all returning to London from the Continent, by steamer, to a port on the Thames, in the early autumn. He would not suggest that the cold air did not flow down the valleys from the higher levels. That was a well-known fact, and for that reason the Swiss cottagers frequently built their dwellings on slight eminences rising above the level of the surrounding ground. It had also been pointed out by Dr. Buchan many years ago that laurels in the lower slopes of the valley of the Tweed had been killed by frost, while the same kind of shrubs on the higher ground had escaped. He had repeatedly seen the mist commencing to rise on the English lakes immediately after sunset in early autumn. At first there was a gentle steaming, gradually increasing in gyrating columns, like the steam escaping from the surface of heated water. It had always struck him as due to the rising of the vapour from the warm water surface, into the colder air lying over it. He had seen the same thing, early in forenoon, in a tidal basin on the Firth of Forth, when the warm water of the sea flowed with the rising tide into a cliff encircled hollow filled with cold air, dense clouds of steam hanging over the incoming stream. The inversion of the normal temperature gradient observed by Mr. Cohen was most interesting, and he hoped that the investigation would be carried farther. If thermographs could be used on the mountain slope and summit and at the lake level, on normal days as well as during the formation of the mist, more light would be thrown on the problem.

Mr. F. C. BAYARD remarked that probably the mist prevented radiation from the blades of grass. He had frequently seen drops of water at the extremities of blades of grass and leaves of other plants; and even in the greenhouse, where there was generally a slight lowering of temperature in the night, on the following morning the same thing was to be observed. He had noticed that these minute drops were always at the end of the veins in the leaf, and seemed as though they would fall off if held up. He was always in doubt whether they were emanations from the grass itself, or the result of the cold air condensing on the vegetation.

Mr. R. G. K. LEMPFERT said that he had made a comparison of the Ben Nevis and Fort William observations for the days referred to in the paper, and those immediately preceding them, and exhibited a diagram showing the changes of temperature, relative humidity, and vapour pressure, which occurred between

6 p.m. on September 12 and midnight on the 16th. From the 12th to about noon on the 15th the conditions were typically anticyclonic, and the weather was brilliantly fine, the amount of cloud at the summit being given as zero throughout the period, while fog in the valleys was frequently noted during the nights. As was to be expected, the inversion of the normal temperature gradient during the night and early morning was well shown, there being a difference of 13° between the temperatures on the summit (53°·5), and in the valley (40°) at 6 a.m. on the 13th, in marked contrast to the state of affairs which prevailed on the 16th, the day of Mr. Cohen's second ascent. On this day conditions in the north were no longer anticyclonic, a "depression" had appeared in the north-west, and the temperature on Ben Nevis remained below that at Fort William throughout. On the anticyclonic days, diurnal changes of temperature of great amplitude occurred in the valley, while on the summit the ranges were much smaller, and many secondary maxima and minima were shown. Similarly with the humidity. At Fort William this rose to nearly 100 per cent during the hours when mist prevailed, and fell to below 70 per cent during the afternoons, while on Ben Nevis the air remained very dry throughout, the humidity being below 60 per cent, and several marked non-periodic changes were shown, due no doubt to a change in the air supply reaching the mountain. Referring to Mr. Cohen's anticipation of a rise of temperature at the summit during the night, due to the upward displacement of the warm air of the valleys by cold descending air, he pointed out that the rise of temperature on Ben Nevis did actually commence some hours before sunrise on each occasion. On the 12th, when the centre of the anticyclone was very near Ben Nevis, the minimum temperature, 51°, occurred at midnight, and a secondary minimum of 53° was shown at 7 a.m.

Mr. W. MARRIOTT remarked that Mr. J. Aitken, in his paper on "Dew" in the *Transactions of the Royal Society of Edinburgh*, gave much information on the points raised by Mr. Bayard. Many years ago at Greenwich he had witnessed a fog which had rolled up quite suddenly, where a few minutes before the air had been quite clear. In his opinion it was the mixing of a cold air with a warmer current that had caused the fog. Some years ago an interesting series of temperature observations were taken at Boston on behalf of the Society; a Stevenson screen was placed in the churchyard, a second screen above the belfry 170 feet above the ground, and a Siemens electrical thermometer at the top of the tower 260 feet above the ground. The observations were taken by Mr. Hackford, the verger of the church, who was a very intelligent man, and whose duties occasionally kept him up all night, and so he was frequently able to take hourly readings throughout a whole day. Some instances of the difference in temperature at the various altitudes during fog would be seen from the accompanying table (*Quart. Journ. Roy. Met. Soc.*, vol. 13, p. 272).

1882.	Churchyard. 4 ft.	Belfry. 170 ft.	Tower. 260 ft.	Remarks.
	°	°	°	
March 15, 9 p.m. . .	45·1	...	51·7	Fog.
,, 18, 9 a.m. . .	41·4	43·8	45·9	Fog, but bright at top of tower.
October 9, 9 a.m. . .	44·5	46·2	48·1	Dense fog at 9 a.m, bright sun at top of tower.
,, ,, 11 a.m. . .	50·7	...	52·0	
November 18, 9 a.m. .	29·0	32·4	34·6	Fog at 9 a.m., bright at top of tower.
,, ,, 11 a.m. .	34·0	...	35·5	
December 12, 9 a.m. . .	26·5	26·2	33·2	Dense fog.

Mr. Marriott also mentioned that on one occasion, whilst staying at Maker Vicarage, the Rev. P. H. Newnham came to his bedroom in the early morning and asked him to look out of the window and see the fog covering Plymouth

Sound. This phenomenon is illustrated in G. Harvey's Article on "Meteorology" in the *Encyclopædia Metropolitana*. Mr. G. W. Ormerod had also described a similar phenomenon at Teignmouth known as "The Larry" (*Quart. Journ. Roy. Met. Soc.*, vol. 9, p. 110).

Mr. Marriott exhibited some lantern slides of fog effects at Malvern and at Ben Nevis, and also some slides taken from the illustrations in Mr. M'Adie's recent work on the *Climatology of California*, representing some very fine fog effects at the Golden Gate, San Francisco.

Mr. H. SOUTHALL remarked that at Ross, where the Wye valley was half a mile wide, he had frequently noticed the fog or mist rising from the river and creeping up the hillside, but never once had seen it drifting down the hill. Occasionally the whole valley was filled with the fog to the height of about 600 feet, and when viewed from above it had the appearance of a level plain or an expanse of the sea. In fact, strangers who had arrived overnight, on looking down the valley in the morning when the phenomenon was to be observed, quite thought they were close to the sea. He had no instrumental readings to support his observations, but he could not quite agree with Mr. Cohen's conclusions.

Mr. BALDWIN LATHAM said that he had made numerous observations upon fog lines, especially with reference to the movements of underground water; and often in the autumn underground streams of water could be traced on the surface of the ground by means of the lines of fog. This, however, only occurred when the temperature of the ground above the water line was higher than the temperature of the water, and there was a clear sky immediately after sunset, and considerable radiation taking place which rapidly cooled the air over the surface of the ground. It would then often be seen where the currents of underground water existed. If the underground flow of water was small in volume, distinct runs of fog were discernible on the surface, often only a few yards wide, and perhaps not more than 18 inches in height, and as white as snow, lying in particular directions, leaving the rest of the field free from fog. In other cases he had found, as in the Caterham Valley near Croydon, in which a large volume of subterranean water flows down, that in this case the fog line was raised above the surface of the ground as a distinct stratum formed some feet above the ground surface, into which often the smoke of the neighbourhood mingled. He was entirely of opinion that autumn fogs were due to the differences of the vapour tension,—that is, the water, being warmer than the air, gave off vapour which condensed in the cooler air; and this would account for both the cases of fog on ground and over water, as, in the case of fog over water, the water was invariably warmer than the air immediately above it. The appearance of fog was therefore simply a question of the difference of temperature, the temperature of the water on the one hand and of the air on the other.

Mr. J. E. CLARK said that it was to be expected that the cold air would flow to the lower level. At the Backhouses' nursery grounds at York, on a clear night, a difference of 2° in the minimum temperature was often recorded between the upper and lower parts, although the difference in level was only 20 feet in 200 yards or so. He had frequently noticed too, on the Yorkshire moors, that a stone wall would be sufficient to hold back the cold air; and while, just above one, the bracken was killed, yet, both higher up and below, it had escaped. It was not only on sloping ground that fog or mist was due to air being cooled sooner than water or marsh, for he had often noticed the same on very level ground directly after sunset. He agreed that one cause of fog was frequently the mixing of air currents. He remembered some years ago, at Bridport Harbour, during a thick fog, that although the land breeze was blowing so strongly down the valley that it was necessary to hold on one's hat,

yet on reaching the pier it was found that a warm south-west wind was blowing in direct from the sea, and that a barque with full sails set was making straight for the harbour, though not a quarter of a mile off. This was seen through a sudden break in the "sea-fog," which passed landward into low fleecy cloud, not 20 feet overhead at the pier-head. The "steaming" of rivers in intense frost, and of asphalt when the sun shone out after a sudden cold shower, were similar in origin.

Mr. J. HOPKINSON thought that the paper scarcely justified its title, "The Cause of Autumn Mists." It should either be "A Probable Cause," or "In Mountain Valleys" should be added, for the cause assigned by the author, although doubtless adequate under certain conditions, could not be the only one. In his own meadow at Watford, on a high plateau of gravel on chalk, he had frequently noticed a layer of mist hanging over a part where there was clay in the gravel, while the air above the rest of the meadow was clear, and there was no higher ground near for a cold stratum of air to descend from. If the theory of dew of Dr. Wells were correct, as he believed it to be, he scarcely thought that the term "false-dew" was required.

Dr. W. N. SHAW, in reply to Dr. Mill, explained that the air nearer the mountain slopes being cooled more than the air at the same level farther off, downward convection would ensue in spite of dynamical warming. In Mr. Dines' kite experiments at Crinan it was always found that the temperature of the free air was above that of Ben Nevis at the same level, sometimes by many degrees; consequently sliding down of the air close to the mountain would take place. Dr. Mill had referred to what might be called boiling-pot fog. In that case fog was formed by the mixing of the vapour from the heated water with air flowing in from the sides of the vessel. The fog was, however, not persistent unless there were a persistent supply of cold air; if the air was stationary, a clear space would be found over the surface of the water. With regard to Mr. Southall's remarks upon fog spreading from the Wye up the valley, he would offer as an analogy the fact that in a flood, although the flood-water apparently came from the river, yet in reality it was the land which fed the river and caused it to overflow; in the same way the cold air forming fog flowed from the higher ground towards the river and then gradually appeared to creep back again as the lower levels were filled up. He thought Mr. Latham's lines and patches of fog might be due to local evaporation. An exaggerated instance of the formation of fog by local evaporations was furnished in the funnel of the locomotive, over which a cloud was formed by the mixing of the escaping steam with the air. He could not agree with Mr. Hopkinson's suggestion that the title of the paper should be altered to "The Probable Cause of Autumn Mists." The author had carried his reasoning beyond mere probability. If it were desired to be extremely precise, the title might perhaps be changed to "One Cause of Autumn Mists." Mr. Hopkinson had also spoken of one fog which he said was certainly not due to cold air. "Certainly" was a strong word to use in speaking of such phenomena, unless it was supported by specific measurements; the motions of cold air were so insidious that very careful measurements were required before certainty upon such a subject could be obtained.

The PRESIDENT (Capt. D. WILSON-BARKER) said that the paper was an interesting one, but he would have liked to see more temperature observations taken at different altitudes at short intervals. More valuable results might then have been obtained. He was inclined to agree with Mr. Latham's conclusions with regard to the probable cause of the fog. From his position on the river at Greenhithe he had had many opportunities of watching the formation of fog, and had frequently noticed that whereas the land was comparatively clear, the river was enveloped in a dense fog. There was no doubt

that the cause of this difference between the land and the water was the much higher temperature of the river at night time. Mr. J. Aitken, in his treatise on dew, fully explains the cause of this phenomena. He thought Dr. Shaw was to be thanked for reading the paper, and for the explanations he had given.

Meteorological Observations at Wadi Halfa.—The *Meteorological Report* for 1901, published by the Survey Department, Public Works Ministry, Cairo, contains the monthly and yearly mean values for temperature and humidity at Wadi Halfa for the 10 years 1891-1900. The mean values for the 10 years are given in the following table:—

Month.	Temperature.							Relative Humidity.	
	Means.			Extremes.					
	Mean.	Max.	Min.	Max.	Year.	Min.	Year.	9 a.m.	9 p.m.
	°	°	°	°		°		%	%
January . .	59·7	73·8	47·5	93·9	1894	34·0	1899	42	44
February . .	62·6	77·2	48·4	99·0	1895	35·1	1896	39	36
March . .	71·4	87·4	56·5	109·9	1894	41·0	1892	30	30
April . .	80·4	95·9	63·7	116·1	1900	48·0	1893	23	24
May . .	87·8	104·4	70·5	116·1	1900	56·5	1900	17	19
June . .	90·7	106·9	74·3	118·9	1899 1900	62·1	1892	20	22
July . .	90·5	105·2	74·5	114·1	1899	57·0	1898	23	30
August . .	90·0	103·6	75·0	111·0	1893 1899	57·9	1898	31	34
September .	86·7	99·7	73·6	116·1	1899	55·0	1898	35	38
October . .	82·6	97·2	69·1	116·1	1899	55·9	1897	37	40
November .	70·9	84·9	58·6	102·0	1900	41·0	1897	41	43
December .	63·0	76·5	51·1	93·0	1900	37·0	1897	45	45
Year . .	78·0	92·8	63·6	118·9	1899 1900	34·0	1899	32	34

The rainfall at Wadi Halfa during the 10 years was practically *nil*. Drops were only recorded 15 times during the period.

The Transvaal Observatory.—This new meteorological institution is built on a range of hills 3 miles north-east of the city of Johannesburg. Its altitude is 5900 feet above sea level. Its latitude is 26° 6′ south. The instruments now being fixed there include a Sprung-Fuess barograph, a Dines-Baxendell anemometer and pressure plate, Callendar platinum resistance thermographs, Callendar sunshine recorder, Hoser lightning recorder of the type sent to the St. Louis Exhibition, Zeiss distance finder for work on clouds, Halliwell rainfall recorder, as well as complete sets of the more usual meteorological instruments. There are 24 outside barometer stations, mostly at altitudes of 4000 feet or more, and 198 rainfall stations, but the authorities are endeavouring to double this latter number in the coming season.—*U.S. Monthly Weather Review.*

REPORT OF THE COUNCIL

FOR THE YEAR 1903.

[Submitted to the Annual General Meeting, January 20, 1904.]

IN presenting their Report, the Council desire to congratulate the Society on the steady increase in the number of Fellows. The expenditure of the past year was heavy, owing in a great measure to the cost of providing accommodation for the magnificent bequest of Mr. Symons, and cataloguing his books, and is thus of a temporary nature.

During the year four Fellows have died who were over ninety years of age, viz. Mr. James Glaisher, F.R.S. (93 years), the sole surviving Founder of the Society, Sir Charles Nicholson, Bart. (95 years), Mr. A. Follett Osler, F.R.S. (95 years), and Mr. William Vicary (92 years).

Committees.—The Council have been materially assisted by several Committees during the year, which were constituted as follows:—

EDITING COMMITTEE.—Messrs. F. C. Bayard, R. Bentley, R. Inwards, and R. H. Scott.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. R. Bentley, R. Inwards, and B. Latham.

KITE COMMITTEE.—The President, Secretaries, Messrs. R. H. Curtis and W. H. Dines, and Capt. M. W. C. Hepworth.

Lecture.—A popular lecture on "The Passage of Sound through the Atmosphere," illustrated by numerous lantern slides and experiments, was delivered on March 18, by Mr. C. V. Boys, F.R.S., in the lecture theatre of the Institution of Civil Engineers, and was greatly appreciated by a large audience.

Meteorological Office Grant.—On the invitation of the Committee appointed "to inquire and report as to the distribution by the Meteorological Council of the Parliamentary Grant, etc.," the Council requested the President to represent the Society, and give evidence before the Committee on several matters as to which it was desirable that the Committee should be informed. The President duly attended the Committee on March 13, and gave evidence on behalf of the Society. The Council have not yet received any information as to the Committee's Report.

Symons Memorial Medal.—The Council, at their meeting on October 21, designated Hofrath Dr. Julius Hann, of Vienna, as the recipient of the Symons Gold Medal for 1904 in consideration of his eminent services to the science of Meteorology.

Howard Medal.—The Howard Silver Medal to the cadets of the Nautical Training College, H.M.S. *Worcester*, was awarded to Cadet H. Wormell for the best essay on "The use of Clouds in forecasting the Weather."

Kite Committee.—The work of this Committee has been continued. The British Association granted £75 towards the expenses. The Admiralty arranged to place a vessel at the disposal of the Royal Society

for the use of the Committee, and when the vessel was not available, in consequence of an accident, the Royal Society granted £200 from the Government Grant Fund. The vessel then obtained at short notice proved, however, to be not so suitable as the Committee desired. The total receipts of this Committee were £275, and the expenditure was £183 : 7 : 6, leaving a balance of £91 : 12 : 6. Mr. Dines carried out the experiments at Crinan on the West Coast of Scotland during the past summer, and notwithstanding the unfavourable weather and unsuitable vessel, he succeeded in obtaining about twenty records, with the loss of one kite, a mile of wire, and one set of instruments. Mr. Dines trusts to be able to present a report of the results at the February meeting in 1904. The Council again desire to acknowledge their deep indebtedness to Mr. Dines and his two sons, for the time and attention they have devoted to the work, and the skill and success with which they have overcome all difficulties. The British Association has made a further grant of £50 towards next year's observations.

Meteorological Exhibition at Southport.—In connection with the session of the International Meteorological Committee at Southport in September, at the time of the meeting of the British Association there, it was decided to hold a Meteorological Exhibition. A committee was formed for this purpose under the auspices of the Meteorological Council, with Dr. W. N. Shaw as chairman, and the Council requested the President and Mr. Baldwin Latham to act as the representatives of the Society thereon. The Society also lent a number of instruments, photographs, etc., for exhibition. It is satisfactory to know that the Exhibition was very successful, and that it formed one of the most attractive features of the Meeting of the British Association.

Research Fund.—This Fund is represented by the sum of £65 : 6 : 10 2½ per cent Consols. The Council are anxious to see it augmented, as it may, this year, be called upon for the Kite Experiments.

The late James Glaisher, F.R.S.—At the invitation of Dr. J. W. L. Glaisher, F.R.S., Mr. Marriott visited Croydon and selected for the Society a number of books, pamphlets, instruments, etc., which belonged to the late Mr. James Glaisher, F.R.S. In addition to these, Dr. Glaisher also presented to the Society the instruments used by his father in his balloon ascents, and marble bust presented to him in 1887. The Council have conveyed to Dr. Glaisher the thanks of the Society for these valuable gifts.

Meetings.—With the exception of those in February, May, and June, which took place in the Society's rooms, the Meetings of the Society were held as usual, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster.

Quarterly Journal.—The Volume for 1903 consists of 327 pages, and contains the papers read at the Meetings of the Society, with the discussions thereon, and numerous notices of meteorological interest. The following amongst other papers have appeared during the year :— The Presidential Address by Mr. W. H. Dines on "The Method of Kite-Flying from a Steam-Vessel, and Meteorological Observations obtained

thereby off the West Coast of Scotland"; "English Climatology, 1881-1900," by Mr. F. Campbell Bayard; "The Eclipse Cyclone of 1900," by Mr. H. H. Clayton; "The Prevalence of Gales on the Coasts of the British Isles during the 30 Years 1871-1900," by Mr. F. J. Brodie; "The Meteorological Aspects of the Storm of February 26-27, 1903," by Dr. W. N. Shaw, F.R.S.; and "The Relation of the Rainfall to the Depth of Water in a Well," by Mr. C. P. Hooker.

A new section has been added entitled "Meteorological Literature," and this gives the titles of such papers as appear to be of general interest bearing on Meteorology in the periodicals which are received in the Society's Library.

Meteorological Record.—Five parts have been issued during the year, bringing this publication to June 1903.

Stations.—Observations have been discontinued at the following stations: Bournemouth, Churchstoke, and Harrogate. Observations have been accepted from the following new stations: Painswick, Gloucestershire; Pirbright Camp, near Woking, Surrey; Teignmouth, Devon; and Towyn, North Wales.

Inspection of Stations.—All the stations in the south-east of England, as well as such other stations as could be conveniently visited, were inspected, and found to be on the whole in a satisfactory condition. Mr. Marriott's Report will be found in Appendix II., p. 228.

Phenological Report.—This valuable Report was, as usual, prepared by Mr. E. Mawley, and read at the February meeting. The Society owes its best thanks to Mr. Mawley for his persevering labours in collecting the returns, and in the preparation of the Report.

Library.—The rearrangement and cataloguing of the Library, required by its removal to the present rooms, and by the magnificent bequest of the late Mr. G. J. Symons, is now practically completed. The new store-room in the basement has been furnished with shelves, and the Daily Weather Reports, Second Order and Climatological Returns, and such other works as are but seldom referred to, have been placed there.

The Library now contains the following numbers of separate works:—

Bound Volumes . .	8,026	Maps and Charts . .	212
Pamphlets . .	10,715	Manuscripts . . .	781

Meteorological Bibliography.—During the year 4463 cards have been prepared for the Society's Bibliography. This consists of the titles of all books, pamphlets, papers, and articles bearing on Meteorology, of which any notice can be found.

In addition to the above, 572 catalogue cards of the titles of works bearing on Meteorology, published in the British Isles, have been prepared for the *International Catalogue of Scientific Literature.*

The Council would invite Fellows and others to send to the Society a copy of all meteorological books and papers of which they may be the authors, to ensure that an entry of the same is made in the Bibliography.

Fellows.—The changes in the number of Fellows are given in the following table, which shows an increase of two during the year :—

Fellows.	Annual.	Life.	Honorary.	Total.
1902, December 31	496	150	19	665
Since elected . . .	+46	+4	...	+50
Reinstated	+ 1	...	...	+ 1
Compounded . . .	− 1	+1	...	0
Deceased	−12	−4	...	−16
Retired	−23	...	...	−23
Lapsed	− 5	...	...	− 5
Struck off	− 5	...	...	− 5
1903, December 31	497	151	19	667

Deaths.—The Council have to announce with much regret the deaths of sixteen Fellows, viz. :—

Hubert Airy, M.A., M.D.	elected	Jan.	20, 1897.
William Clinton Baker, J.P.	,,	Feb.	20, 1878.
Edward John Bentley	,,	Nov.	19, 1902.
Sir Frederick J. Bramwell, Bart., F.R.S., M.Inst.C.E.	,,	Apr.	16, 1879.
Rev. Guy Julian Bridges	,,	Jan.	16, 1901.
John Charlton	,,	Mar.	21, 1900.
Charles Henry Gatty, M.A., LL.D., F.R.S.E.	,,	Feb.	16, 1898.
James Glaisher, F.R.S., F.R.A.S.	,,	Apr.	3, 1850.
Moritz Immisch	,,	Apr.	17, 1901.
Sir Charles Nicholson, Bart., LL.D., F.R.G.S.	,,	Jan.	20, 1858.
Abraham Follett Osler, F.R.S.	,,	Apr.	19, 1882.
Thomas F. Read	,,	Dec.	15, 1875.
Lieut.-Col. Harloven Morley Saunders	,,	May	15, 1895.
John David William Vaughan	,,	Nov.	19, 1884.
William Vicary, F.G.S.	,,	Nov.	25, 1856.
Edward Woods, M.Inst.C.E.	,,	Dec.	18, 1889.

[*Appendix I. is given on page* 224.]

Meteorological Service of Japan.—The meteorological service of Japan is under the direction of the Central Meteorological Observatory, and under the supervision of the Minister of Education. The service, which extends over the whole Empire, except Formosa and the Pescadores islands, was initiated by the Imperial Ordinance No. xli., 1887, containing the following six articles :—

1. A central meteorological observatory is to be situated in Tokio and a number of provincial meteorological stations in suitable locations. The sites of these stations shall be determined by the Minister of Education.

2. Any persons who desire to erect meteorological stations besides those above mentioned, shall obtain sanction from the Minister of Education.

3. The central meteorological observatory shall be directly controlled by the Minister of Education, and the provincial meteorological stations by the

governors of prefectures, under the supervision of the Minister. Other meteorological stations shall be placed under the supervision of the governors of prefectures.

4. The expenses of the provincial meteorological stations shall be defrayed from the revenue of the respective prefectures concerned.

5. The central meteorological observatory and the provincial meteorological stations shall be in communication with one another in the execution of their business.

6. The rules for enforcing these regulations shall be fixed by the Minister of Education.

The Central Meteorological Observatory at Tokio was inaugurated on June 5, 1875. There are 134 stations of the first and second order. Observations are made hourly at stations of the first order, and six times a day at stations of the second order. There are also 1214 stations of the third order, which play an important part in the system of rainfall, thunderstorm, and earthquake stations in Japan.

The telegraphic weather service in Japan was organised in February 1882. The Central Meteorological Observatory in its service of prediction acts as the central office of weather telegraphy and of the system of storm warning for the Empire. Telegraphic reports are received three times a day, viz. 6 a.m., 2 p.m., and 10 p.m. Forecasts are generally issued at 8 a.m. and 6 p.m.

The organisation and collection of marine meteorological observations has been carried on since 1888. All ships of the Empire, with a tonnage exceeding 100 tons, make meteorological observations on board and forward the logs to the Central Meterological Observatory.

Special observations of thunderstorms are made. Phenological, seismic, and magnetic observations are also made.

The following is a chronological list showing some of the advances of meteorology in Japan :—

1872.—July 23. The first meteorological station inaugurated at Hakodate.

1875.—June 1. Meteorological service established in the land survey section of the Geographical Bureau. Tri-daily observations commenced.

1882.—January 1. Service of storm warnings established.

1883.—February 16. System of weather telegraphy commenced and weather maps first printed.

1883.—November 1. First storm signal station established.

1884.—May 10. Collection of meteorological telegrams three times a day commenced.

1884.—June 1. Weather forecast first indicated at police stations in Tokio. Weather maps first published three times a day.

1886.—January 1. Hourly observations commenced in Tokio.

1888.—March 10. Weather forecasts for 24 hours in advance first printed in *Official Gazette* and newspapers.

1888.—April 1. Weather maps first printed once a day.

1900.—May 20. School for training meteorological observers first opened.

There is a meteorological observers' training school at the Central Meteorological Observatory. The school is for the members of the provincial meteorological stations, in order to provide such knowledge as is necessary for discharging their regular duty, and to secure more uniformity as well as a higher standard in their attainments. The term of the school usually includes six months, during which time courses of lectures on mathematics, physics, meteorology, seismology, instruments and methods are given with some practical exercises. Meteorological observers of the provincial stations who have proper preliminary education are admitted by recommendation of the governor of the prefectures. The number of graduates have been : 16 in 1900, 27 in 1901, and 18 in 1902—total, 61.

APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1902			£27 11 10
Subscriptions for 1903	£835 0 0		
Do. for former years	66 10 0		
Do. paid in advance	43 0 0		
Life Compositions	105 0 0		
Entrance Fees	43 0 0		
			1092 10 0
Meteorological Office—Copies of Returns	£106 4 0		
Do. Grant towards Inspection Expenses	25 0 0		
			131 4 0
Dividend on Stock (including £47 : 15 : 7 from the New Premises Fund)			149 10 10
Sale of Publications, &c.			41 2 5
			£1441 19 1

I.

FOR THE YEAR ENDING DECEMBER 31, 1903.

EXPENDITURE.

Journal, &c.—			
Quarterly Journal, Nos. 125 to 126	£74 9 0		
Illustrations	27 10 6		
Authors' Copies	8 7 6		
Meteorological Record, Nos. 86 to 87	48 2 3		
		£158	9 3
Printing, &c.—			
General Printing	£26 1 0		
Stationery	18 11 10		
Books and Bookbinding	28 14 6		
		73	7 4
Office Expenses—			
Salaries	£610 12 0		
Rent and Housekeeper	210 10 0		
Coals, Lighting, and Insurance	15 0 10		
Furniture and Repairs	7 4 7		
Postage	67 11 6		
Petty Expenses	24 13 3		
Refreshments at Meetings	14 13 0		
Lecture	10 10 0		
Howard Medals	2 18 6		
		963	13 8
Observations—			
Inspection	£47 13 6		
Observers	11 4 0		
Instruments	1 12 5		
		60	9 11
Stock—			
Purchase of £100 Western Australia Government 3 per cent		92	12 6
		£1348	12 8
Balance—			
At Bank	£85 19 1		
In hands of the Assistant-Secretary	7 7 4		
		93	6 5
		£1441	19 1

Examined, compared with vouchers, and found correct,

T. P. NEWMAN,
DONALD W. HORNER, } *Auditors.*

January 12, 1904.

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

To Subscriptions paid in advance	£43 0 0		
,, Rent for quarter ending December 25, 1903	53 0 0		
,, Quarterly Journal, Nos. 127 to 128	87 14 0		
,, Meteorological Record, Nos. 88 to 90	60 5 0		
,, Printing, &c.	11 16 0		
		£255 15 0	
,, Excess[1] of Assets over Liabilities		3432 4 1	
		£3687 19 1	

[1] This excess is exclusive of the value of the Library, the Stock of Publications, and the Symons Bequest and Bibliography.

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Amount paid to the Society's Fund towards the rent of rooms at 70 Victoria Street	£47 15 7

RESEARCH FUND,

Hire of Vessel, &c. for Kite Observations	£108 7 6
Cash at Bank of England (including £91 : 12 : 6 from Grant for Kite Observations)	92 18 0
	£201 5 6

I.—continued.

ON JANUARY 1, 1904.

ASSETS.

By Investment in Great Central Railway 4½ per cent Debenture Stock, £800 at 130½	£1040	0	0			
,, Investment in New South Wales 4 per cent Inscribed Stock, £654 : 18s. at 107	700	14	10			
,, Investment in Western Australia Government 3 per cent Inscribed Stock 1927, £230 at 87	200	2	0			
,, Investment in London & North-Western Railway Consolidated Stock, £400 at 145½	582	0	0			
,, Investment in London & North-Western Railway 4 per cent Preference Stock, £12 at 120¼	14	8	7			
,, Investment in 2½ per cent Annuities, £231 : 11 : 9 at 87¾	203	4	4			
				£2740	9	9
,, Subscriptions unpaid, estimated at	£50	0	0			
,, Entrance Fees unpaid	11	0	0			
,, Interest due on Stock	55	3	1			
,, Meteorological Office—Weekly Returns, 1903	27	2	7			
				143	5	8
,, Furniture, Fittings, &c.	£565	2	9			
,, Instruments	145	14	6			
				710	17	3
,, Cash at Bank of England	£85	19	1			
,, Cash in hands of the Assistant-Secretary	7	7	4			
				93	6	5
				£3687	19	1

Examined, and securities seen at the Bank of England,

January 12, 1904. T. P. NEWMAN, DONALD W. HORNER, } *Auditors.*

DECEMBER 31, 1903.

Interest received on Investment	£47	15	7	

Note.—The Society holds on account of this Fund £1443 : 7 : 9 South Australian 3½ per cent Inscribed Stock.

Examined, and certificates seen at the Bank of England,

January 12, 1904. T. P. NEWMAN, DONALD W. HORNER, } *Auditors.*

DECEMBER 31, 1903.

Interest received on Investment	£1	5	6
Government Grant Committee for Kite Observations	200	0	0
	£201	5	6

Note.—The Society holds on account of this Fund £65 : 6 : 10, 2¾ per cent Consols.

Examined,

January 12, 1904. T. P. NEWMAN, DONALD W. HORNER, } *Auditors.*

APPENDIX

SYMONS MEMORIAL

Balance from 1902	£5 11 1
Interest received on Investment, 1903	19 0 7
	£24 11 8

APPENDIX II.

INSPECTION OF STATIONS, 1903.

The stations east of 2° W. long. and south of 52° N. lat., as well as several others, have been visited, and have been found to be generally in a very satisfactory condition. It is a great pleasure to see some stations, as the instruments are kept very clean and the observers are heart and soul in the work. At two or three stations, however, the instruments are allowed to get very dirty, and where such is the case there is but little pride and interest taken in the observations.

The number of thermometers tested has been 247, in 45 of which there was found to be a change of zero. Ten rain measuring glasses have also been tested. WM. MARRIOTT.

October 1903.

NOTES ON THE STATIONS.

ADDINGTON, *August* 6.—This station was in good order, and the observations appeared to be satisfactorily taken. On comparing the thermometers, it was found that the dry and wet had both gone up 0°·1 and the maximum 0°·2.

ALDERSHOT, *July* 2.—This station is at the Sewage Works. The exposure is open, but the proximity of so many tanks and filter beds for the treatment of the sewage probably makes the air rather damp. I urged the observer to keep the muslin and cotton on the wet-bulb clean; and I recommended that the maximum and minimun thermometers be lowered in the screen, so as not to intercept the readable part of the scales of the dry and wet. The grass was long, and almost hid the rain-gauge.

BEDDINGTON, *August* 6.—This station was in a satisfactory condition. There was no change in any of the thermometers.

I.—continued.

MEDAL FUND, 1903.

Cash at Bank of England, December 31, 1903	£24 11 8
	£24 11 8

Note.—The Society holds on account of this Fund £630 Cardiff Corporation Redeemable Stock, 3 per cent.

Examined, and securities seen at the Bank of England.

January 12, 1904. T. P. NEWMAN, DONALD W. HORNER, } *Auditors.*

BENNINGTON, *September* 30.—This station was in good order. There was no change in the zeros of the thermometers.

BERKHAMSTED, *October* 9.—This station was in good order. On comparing the thermometers, it was found that the grass minimum had gone down 0°·6.

BEXHILL, *July* 23.—Miss A. Scrivens having removed from Bexhill, the observations are now taken by Mr. Brisley. The instruments are placed in a railed-off enclosure on the grass plot on the south side of the Marina. The exposure is open, but it is rather close to the sea. The rain-gauge should be moved about 2 ft. to the north. The Campbell-Stokes sunshine recorder is mounted on a post about 12 ft. high. It is probable that the houses on the east-north-east and west-north-west may intercept a little of the early and late sunshine.

BLACKPOOL, *September* 12.—The sunshine recorder was temporarily placed on the roof of the Sanatorium: the instrument was not quite level. There was a little spirit at the top of the tube of the minimum thermometer. The Negretti and Zambra self-recording rain-gauge needed overhauling and cleaning. A new site has been obtained for the instruments, about half a mile to the north-east of the Sanatorium. An enclosure about 24 ft. square has been railed off in a field, and about 60 ft. to the north of it has been erected a brick building on the top of which the sunshine recorder and the Dines anemometer are to be placed. The field belongs to the Corporation, and the exposure is very open. The instruments were to be removed to the new site very shortly.

BOGNOR, *July* 15.—This station was in good order. A 4-ft. earth thermometer has been added since the last inspection. This consists of a Six thermometer with maximum and minimum indices.

BOURNEMOUTH, *August* 22.—This station was in a very satisfactory condition, and the instruments were in good order. In addition to the usual instruments, Mr. Colvile has a barograph, a thermograph, and a Halliwell self-recording rain-gauge. The sunshine recorder required adjusting, as the trace was 12 minutes fast.

BRIGHTON, *July* 14.—The muslin on the wet-bulb required changing. I recommended that a glass vessel larger than the present copper receptacle be

used, and that it be placed nearer the bulb. The grass minimum had some spirit up the tube. The ball of the sunshine recorder was too high, and the instrument had recently been turned too much on one side.

CHELMSFORD, *August* 27.—This station was in good order. On comparing the thermometers, it was found that the wet-bulb had gone up 0°·1.

CHELTENHAM, *July* 8.—The instruments had been removed from the late Mr. R. Tyrer's residence to the Montpelier Gardens, and were placed in an enclosure 15 ft. square. I recommend that the rain-gauge be moved to the position of the grass minimum thermometer, and that the rim be only 1 ft. above the ground. The minimum and grass minimum thermometers had some spirit up the tube. On comparing the thermometers, it was found that the wet-bulb had gone up 0°·2, and that both the minimum and the grass minimum had gone down 0°·7. The barometer was placed in the pay-office to the Montpelier Spa, which was a very confined and close room. The instrument was not hanging quite perpendicular. I recommended that it be removed, if possible, to the observer's house. I found that the observer had been reading and setting the minimum and the grass minimum thermometers at 9 a.m. instead of at 9 p.m.

CRANLEIGH, *July* 3.—The instruments were in good order. I recommended that a new water receptacle be obtained, and I gave the observer instructions about the management of the wet-bulb during frost. The minimum thermometer is graduated from − 55° to + 140°.

DORCHESTER, *August* 15.—The instruments are placed on the top of the covered reservoir at the Water Works. The exposure is good, except for the sunshine recorder, as a row of trees from the east by south to south-west make a considerable angle. I recommended that the recorder be moved to another spot, and raised about 10 ft. above the ground, where it would have a much better exposure. I also recommended a rearrangement of the thermometers in the screen, and explained to the observer the methods to be adopted with regard to the management of the wet-bulb and to the measurement of snow.

EASTBOURNE, *July* 23.—On comparing the thermometers, it was found that the wet had gone up 0°·1 and the minimum 0°·3. Cross-pieces to the legs of the thermometer screen would considerably strengthen it.

FOLKESTONE, *July* 21.—The water receptacle was a considerable distance from the wet-bulb, so that the conducting thread made a regular bend. I recommended that the receptacle be placed nearer the bulb, in order to allow the conducting thread to work freely. As the rain-gauge was placed close to a sloping bank, I recommended that it be moved about 15 ft. farther away.

GRAYSHOTT, *July* 10.—The instruments had been moved the previous year a little farther to the east, to a more open site. The instruments were in good order. As the minimum was liable to have the index shaken down by the wind, I suggested that one of the screws be lowered. The sunshine recorder was in good adjustment. I recommended that certain fir trees be topped in order not to intercept the early and late sunshine.

GUERNSEY, *August* 17.—On comparing the thermometers, it was found that the dry and wet had both gone up 0°·1. The tube of the minimum is liable to slip down if not securely fastened. The 5-in. monthly rain-gauge had been moved to a new garden, where it has a very good exposure. I recommended that it be placed on the grass with the rim 1 ft. above the ground.

HALSTEAD, *August* 27.—The muslin on the wet-bulb needed changing. On comparing the thermometers, it was found that the dry and wet had both gone up 0°·1. The funnel of the rain-gauge required soldering. The mercury

in the cistern of the barometer was very much corroded. I recommended that it be cleaned.

HARESTOCK, *August* 24.—The station and instruments were in good order. Col. Knight has a large number of meteorological instruments, and devotes a considerable amount of time to reading them and entering up the observations. I counted 32 thermometers, 2 rain-gauges, 2 anemometers, 2 evaporation tanks, barometer, sunshine recorder, and wind vane in use. I urged Col. Knight not to change the thermometers so frequently, as with the deep-earth thermometers it is a considerable time (days) before they take up the proper temperature. Col. Knight sends his thermometers to Kew very frequently for re-verification, as he has numerous duplicate instruments.

MALDEN, *July* 11.—This station is at Worcester Park. The instruments are placed on the lawn of the Manor House, and are well exposed. I recommended that the positions of the maximum and minimum in the screen be altered. On comparing the thermometers, it was found that the dry had gone up 0°·3 and the wet 0°·2, and that all the earth thermometers were 0°·2 too high.

MALMESBURY, *July* 7.—This station is at Cowbridge House, about 1½ miles south of Malmesbury. The instruments are placed on a grass plot in the kitchen garden. The door of the screen opened to the south-east. I recommended that the screen be shifted, so that the door should open to the north-west; also that the screen be placed farther from the asphalt path, and that the grass plot be made larger.

MARGATE, *July* 20.—The instruments are now placed on the lawn of Westlands, Grosvenor Place. The minimum thermometer had 0°·6 spirit up the tube. On comparing the thermometers, it was found that the wet-bulb had gone up 0°·1. The thermometer screen needed to be mounted on new posts. The sunshine recorder is placed on the old Water Tower, near College Road, where it has a good exposure.

MARLBOROUGH, *July* 6.—The muslin and the cotton required changing, and the water receptacle to be kept clean. These were green, owing to clean water not being used. The grass was much too long, and was covering the earth and grass minimum thermometers. A row of peas was growing too close to the rain-gauge. The grass minimum had 2° of spirit up the tube. On comparing the thermometers, it was found that a change had taken place in most of them. The sunshine recorder was not in proper adjustment, as the trace was not parallel with the card.

NORWOOD, *July* 25.—Owing to the growth of trees in a neighbouring garden, a 5-in. rain-gauge was obtained some time ago and placed 17 ft. north-west of the 8-in. gauge. For the first year there was no difference in the amounts collected by the two gauges, but in the second year the old gauge showed a slight falling off. The rainfall is now reported from the 5-in. gauge.

OLD STREET, E.C., *October* 16.—This station was in good order. On comparing the thermometers, it was found that the maximum had gone down 0°·3. The rain-gauge had been interfered with on several occasions. Some months previously the funnel had been stolen. The Rev. F. J. Sugden is of opinion that a boy had taken it in order to use the pipe for a pea-shooter. The top of the new gauge is now only 6 ins. above the ground, so as not to be so conspicuous as formerly, and the inside pipe has been shortened.

PIRBRIGHT, *July* 2.—This station is at Pirbright Camp, about 1¼ mile from Brookwood Railway Station. The situation is very open, and the soil

being sandy, there is a considerable amount of dust in windy weather. The instruments were all clean and in good order. As the maximum and minimum thermometers only had circular suspenders, I gave the observer back-plates with hole and slot to put on instead.

PORTSMOUTH, *July* 15.—The instruments are now placed in a railed-off enclosure in the Victoria Park, and have a good exposure. I was informed that Mr. Harries, of the Meteorological Office, had inspected this station the previous day, and that he had tested the thermometers, so I did not re-test them. The 1-ft. earth thermometer had been found to be 0°·5 too high, so it had gone up 0°·3. The wet-bulb had not been working properly at times, but more attention will now be paid to this. The screen was considerably lower than usual, the posts having been cut when it was removed from the Milton Hospital. Pending a new screen being made, I recommended that the maximum and minimum thermometers be raised 1 or 2 ins. higher.

RAVENSCAR, *September* 22.—The observer had been greatly troubled with the spirit in the minimum thermometer getting to the top of the tube. A second thermometer had been obtained, which, however, acted in the same manner. I examined the instruments and the screen, and also questioned the observer, but could not find any apparent reason for the thermometers getting out of order. I gave the observer directions how to set the thermometers right in the event of their getting out of order again.

REGENT'S PARK, *October* 16.—The muslin on the wet-bulb required changing. I recommended that the thermometer screen be cleaned inside. There was a little detached mercury up the tubes of the 6-in. and 1-ft. earth thermometers. The sunshine recorder was in good adjustment. A flagstaff on the south-south-west intercepts the sunshine for 5 to 10 minutes.

ROUSDON, *August* 13.—This station was in good order. The sunshine recorder was placed in the meteorological enclosure for the summer months. I recommended that it be removed to the anemometer tower, as the trees on the east-north-east and west-north-west were likely to cut off some of the early morning and late evening sunshine. The various self-recording instruments were in good working order. The "head" of the Dines anemometer had recently been cleaned, and a new spindle had been put in the Robinson anemometer. On comparing the thermometers, it was found that the wet-bulb had gone up 0°·2, and both the 2 ft. and 4 ft. earth thermometers 0°·1.

SALCOMBE, *August* 11.—The minimum thermometer had a little spirit at the top of the tube; and there was also a bubble of air just below the index. The water receptacle was too close to the wet-bulb, as it almost enclosed the bulb. The sunshine recorder, which has Curtis's arrangement, is on the top of the covered reservoir at the summit of the hill above St. Dunstan Road. The exposure is quite open. The recorder is placed on a bed of cement on the ground.

SCARBOROUGH, *September* 23.—A large dish of water was placed under the wet-bulb thermometer. I recommended that this be removed, and a small glass vessel with a cover be used instead. The spot of light on the sunshine card was exactly on the central line and on the hour line at 12 o'clock noon this day, showing the recorder to be in good adjustment.

I saw the chairman of the Meteorological Committee, who was very desirous of having the instruments removed from the Peasholme Allotments. The new site recommended is the lawn in front of the Town Hall. The reasons for this are that the instruments will be on Corporation ground, and that they will be much more accessible for the observer. Also, being at the Town Hall, they will be more under supervision. The site is close to the cliff, but it is within

a few yards of the spot where the instruments were placed some years ago. The instruments at the Manor Road Nursery are to be continued for at least a year, so it will be possible to see whether there is any difference between the various places. The sunshine recorder is to be placed on the tower of the Fire Station, where the exposure will be very good.

SHAFTESBURY, *August* 21.—The column of spirit in the minimum thermometer was much broken up by air-bubbles: this I succeeded in getting right. The muslin and cotton on the wet-bulb were dry, the end of the cotton not reaching to the bottom of the water receptacle, which was nearly empty. The rain gauge, I learned, had been occasionally moved. I urged that it be kept in one place only.

SOUTHPORT, *September* 19.—This station was in a very satisfactory condition. During the meeting of the British Association, I conducted a number of the Members, including most of the International Meteorological Committee, over the Observatory, who were very pleased with the whole of the arrangements, and expressed the hope that the Observatory would always be maintained in its present high state of efficiency.

SWARRATON, *August* 25.—On comparing the thermometers, it was found that the dry, wet, and maximum had gone up 0°·1. I gave the observer instruction as to the measurement of snow, and as to the management of the wet-bulb in frost.

TEIGNMOUTH, *August* 12.—The instruments are placed in a railed-off enclosure on one of the small grass plots at the south end of the Den next to the Coast Guard Station. An asphalt path about 15 ft. wide separates the enclosure from the parapet above the shore. The exposure is very open. As it was proposed to have a Campbell-Stokes sunshine recorder I suggested that it be mounted on the top of a lamp-post frame, and that the enclosure be lengthened for this purpose. The water receptacle was too close to the wet-bulb—in fact almost surrounding it. The grass minimum had some spirit up the tube.

TENTERDEN, *July* 21.—The Jordan sunshine recorder is placed in the front garden in the morning, and in the back garden in the afternoon. There are some trees on the east-north-east and a house on the south-east which may intercept the early morning sun, and a tree on the south-west the afternoon sun. The barometer was not hanging vertically owing to the wall not being perpendicular.

THURLOW, *October* 8.—The conducting thread was much too thin, being only two strands. I recommended that a better conductor be used, and also that the water receptacle be placed farther from the bulb and that a cover with a hole be put over it. I suggested that a wooden grid or a flat stone be placed on the grass in front of the thermometer screen to stand on.

TUNBRIDGE WELLS, *July* 24.—The instruments were in good order. On comparing the thermometers it was found that the minimum had gone down 0°·2. A new Campbell-Stokes sunshine recorder had been obtained in April and was working satisfactorily. I found that the measurement of the trace had been made along the central line of the card and not along the actual burnt record. Heavy rain had fallen during the previous night, the amount measured that morning being 3·77 ins.

VENTNOR, *July* 16.—I recommended that a cover be placed over the water receptacle. I learned that in frost the observer removed the cotton and muslin from the wet-bulb and then wetted the bare glass bulb. I explained that this was not the proper method, but that the muslin should be wetted on

the bulb. The sunshine recorder was in good adjustment. I recommended that some bushes and shrubs on the east-north-east be cut back, in order to prevent them intercepting the early morning sunshine.

WALLINGTON, *August* 6.—The instruments were in good order. Mr. Bayard proposed placing an 8-in. Glaisher rain-gauge (with straight pipe) at 1 ft. above the ground. On comparing the thermometers, it was found that the dry, wet, and a spare thermometer had all gone up 0°·1.

WEYMOUTH, *August* 14.—The instruments are in the same position as at the last inspection. The trees have grown very much. I recommended that they be cut. On comparing the thermometers, it was found the dry had gone up 0°·2 and the wet 0°·1. The sunshine recorder, which is at the end of the pier, is so placed that it is very difficult, and in rough weather very risky, to get at. The recorder was not in proper adjustment, being about ¾ hr. fast. Mr. Brown and I went to the Royal Hotel and saw the manager, with the view of getting the sunshine recorder placed on one of the turrets of the Hotel.

WINTERSLOW, *August* 20.—This station was in good order. As the tube of the maximum thermometer was liable to slip, owing to the knob at the end having been broken off, I succeeded in fixing it by means of a tack and a small piece of wood. The grass minimum had some spirit up the tube.

WORTHING, *July* 14.—The instruments were in good order. I recommended that a fresh glass vessel be obtained for the wet-bulb. The ball of the Campbell-Stokes recorder was a little too high. Some trees on the east-north-east intercept a little of the early morning sunshine.

APPENDIX III.

OBITUARY NOTICES.

HUBERT AIRY was a son of the late Sir G. B. Airy, Astronomer Royal, and was born on June 14, 1838. He was educated at the Blackheath Proprietary School and at Trinity College, Cambridge. He graduated in 1861 with first class honours in Classics and third class honours in Mathematics. After taking his B.A. degree, he remained some years longer at Cambridge and studied Medicine and Surgery there, and took his degree of M.D. He then entered at Guy's Hospital in London, and went through the usual curriculum with much credit.

He had during his studies suffered from a severe and continuous course of headaches, and did not like the idea of practising in the usual way. He was, however, fortunate enough to obtain an appointment as one of the Medical Inspectors under the Local Government Board, and the rest of his working life was spent in this employment. His duties were mainly in connection with the administration of the laws relating to vaccination; but he was often required to write reports on outbreaks of epidemics, and the sanitary condition of hospitals, seaports, etc. His district comprised the five Eastern Counties, and for reasons of convenience he settled at Woodbridge in Suffolk, where he died on June 1, 1903. His health had broken down so seriously some few years earlier, that he had given up his appointment, and did not die in harness.

Dr. Airy was a man of singularly amiable disposition, generous and helpful, and much liked and respected. He had a wide range of knowledge and interest, and was essentially an "all round" man. He was well

read in classical literature, and took much interest in general literature, mechanics, physics, and natural history. His interest in Meteorology was very pronounced, and he did all he could by his example to promote the study of it in the town where he lived. He contributed papers to the Royal Society on the subjects of Hemiopsia and Phyllotaxy, and occasional letters to *Nature* and the *Medical Journal.*

He was elected a Fellow of this Society on January 20, 1897.

WILLIAM CLINTON BAKER died at Bayfordbury, in July 1903, after an illness of some weeks, in his 64th year. In early life he was a Captain in the Hertfordshire Militia, and subsequently was an officer in the Hertford Volunteer Corps. He had been a Justice of the Peace for Herts for many years, and was the senior acting member of the Hertford County Bench. Mr. Baker was elected a Fellow of this Society on February 20, 1878; and as a botanist he took a keen interest in maintaining the well-known Pinetum at Bayfordbury established some seventy years ago by his late father, and in preserving the fine old trees for which the estate is noted.

For many years he contributed to the *Hertfordshire Mercury* daily records of meteorological observations as taken at Bayfordbury.

EDWARD JOHN BENTLEY was a great-grandson of Edward Bentley, publisher, a grandson of John Bentley, Secretary of the Bank of England, and the eldest son of Dr. Edward Bentley, a very active physician who died in early life, and to whose exertions the foundation of the Pathological Society and the City of London Hospital for Diseases of the Chest were largely due.

Mr. E. J. Bentley was born in London on December 30, 1844, and for upwards of thirty years was in the service of the Bank of England. After his retirement, owing to the fragility of his health, for he inherited, like his younger brothers who predeceased him, his father's chest delicacy, he resided at Stoke Newington, and latterly at Ramsgate, where he died unmarried.

Greatly interested in flowers, his attention was thereby directed to the influence of the weather upon them, and for some years he furnished records of the rainfall in his locality to the late Mr. Symons. His observations were also published locally in the Stoke Newington and Ramsgate papers—in the latter until within a very short time of his death, which occurred on November 18, 1903.

Mr. E. J. Bentley was elected a Fellow of this Society on November 19, 1902.

Sir FREDERICK JOSEPH BRAMWELL was born on May 7, 1818, and was the youngest son of Mr. George Bramwell, a partner in the firm of Dorrien and Co., bankers, of Finch Lane. His elder brother was Lord Bramwell, the Judge.

In 1834 he was apprenticed to John Hague, a well-known engineer of his time. After the expiration of his indentures he became a draughtsman, and then manager of different engineering establishments. He started in private practice as an engineer in 1853. Much of his early experience was in connection with steam locomotion on common roads, and he was fond of relating his experiences with Walter Hancock and others who, in the first half of the nineteenth century, unsuccessfully

anticipated the present application of mechanical power to ordinary traffic. But it was neither as a civil nor as a mechanical engineer that he achieved his great reputation. He soon found a career in the legal side of the profession. His marvellously clear power of exposition, his quickness of appreciation, his great readiness, his facility for rapid reply and humorous repartee, made him one of probably the ablest scientific witnesses that the courts have ever known; while in later years his great judicial powers made him in constant demand as an arbitrator.

And while his advice and help were sought by litigants in nearly all important law cases of a technical nature, his knowledge and ability were also utilised by the Government. He was one of the two lay members of the Ordnance Committee from 1881. He reported on such subjects as the *Thunderer* explosion, and the site of the Mint, and he served on various departmental committees dealing with boiler explosions legislation, patent law, electric lighting, and the like.

One of the busiest of men—till the end of his life, after a hard day's work he would go home to work far into the night—he found time and vent for his superfluous energy in voluntary labour, which to most men would have supplied sufficient occupation for their whole lives.

In the great Institutions connected with his own profession he was for many years a conspicuous figure. He was President of the Institution of Mechanical Engineers in 1874-75, of the Institution of Civil Engineers in 1884-85, and both Institutions relied upon his assistance to a very large extent in the management of all their business affairs. He was also a Vice-President of the Institution of Naval Architects, and served for many years on its Council. The British Association was another of the institutions in which he took a keen interest, and to which he devoted time and work; and in 1888 he was elected President.

The Royal Institution also occupied for many years much of his thoughts and attention. In 1885 he became its honorary Secretary, and he held this post until 1900. When the very successful series of Exhibitions were held at South Kensington, Sir Frederick Bramwell served as Chairman of the Inventions Exhibition, 1885, and this post was filled with the strenuous care which was characteristic of the man. Finally, when the City and Guilds of London Institute was formed for the promotion of technical education in 1877, he became the Chairman of its Council, as representative of the Goldsmiths' Company, of which company he was at one time Prime Warden.

Sir Frederick Bramwell was elected a Fellow of the Royal Society in 1873. He received the honour of a knighthood in 1881, and of a baronetcy in 1889.

He died on November 30, 1903, at the age of 85 years.

He was elected a Fellow of this Society on April 16, 1879.

CHARLES HENRY GATTY was born at Crowhurst, in Sussex, on March 6, 1836, and was the younger son of Mr. George Gatty, who was a taxing master in Chancery. A keen sportsman and typical English country gentleman, Mr. G. Gatty acquired the Felbridge property, one of the finest sporting estates in the neighbourhood, with its beautiful park and surroundings, by purchase from the late Lord Liverpool; and on the premature death of his elder brother, Mr. C. H. Gatty became heir to the property. He was educated at Trinity College, Cambridge,

and possessed very different tastes from those of either his father or his brother, giving up his whole time to scientific and literary study. St. Andrews University conferred the degree of LL.D. upon him in recognition of services he rendered to it, and he was also a Fellow of the Royal Society of Edinburgh.

After the death of his father in 1864, he lived with his mother at Felbridge until she died in 1876, and subsequently his life became akin to that of a recluse and almost a hermit. Like his father, he was most munificent in his contributions to anything and everything for the public benefit or advantage.

Dr. Gatty was Chairman of the East Grinstead Bench of Magistrates in Sussex, and for years attended the bench at Godstone, in Surrey, of which county he was also a Justice of the Peace. His scientific interests were largely divided between astronomy and botany. He died at Felbridge on December 12, 1903.

He was elected a Fellow of this Society on February 16, 1898.

MORITZ IMMISCH was born in Thuringia, graduated at a German University, and came to London about forty years ago. His work was first directed to the art of watch and clock making, and in 1872 he obtained the Baroness Burdett-Coutts's prize for an essay on "The Balance Spring." He subsequently turned his attention to electricity, becoming one of the earliest pioneers in the development of electric power, and in 1880 he entered into partnership with the late Mr. Fritz Hubel. At their works was produced the "Immisch" motor, which received medals at the Inventions Exhibition of 1885, the Antwerp Exhibition of the same year, and at various subsequent exhibitions. He was the inventor of the Immisch thermometer, which is a watch-shaped instrument, and about the size of a small locket. After a time the Malden Works were closed, and Mr. Immisch retired from manufacturing work. Subsequently he was director of the Immisch Electric Launch Company, of which he was the founder. He died on September 20, 1903.

He was elected a Fellow of this Society on April 17, 1901.

Sir CHARLES NICHOLSON died on November 8, 1903, in his 94th year. After graduating in Medicine with high honours at the University of Edinburgh, he went at the age of 25 to Australia, where an uncle had acquired some property near Sydney, and where he wished to ascertain whether he could himself settle. Having decided to cast in his lot with the fortunes of the young colony, he at first devoted himself with ardour and success to the medical profession. Thereafter he acquired a partnership in a sheep-station, and was gradually drawn into active participation in all the social and political development of the community.

He became a Member of the first Legislative Assembly of New South Wales, and took such a leading part in its deliberations that he was thrice elected Speaker of the Chamber. His interest in educational progress was especially deep and enlightened. He had an active share in the foundation of the University of Sydney, and was for a number of years the Chancellor of that flourishing institution, endowing it with many valuable gifts, some of which—such as the collection of Egyptian

antiquities, which he himself made in Egypt—had a high educational value.

He eventually returned to this country, and spent the latter years of his life at the Grange, Totteridge, Hertfordshire. He was knighted in 1852, and in 1859 was made a Baronet.

He was elected a Fellow of this Society on January 20, 1858.

ABRAHAM FOLLETT OSLER died on April 26, 1903, at Edgbaston, Birmingham, at the age of 95. Mr. Osler devoted himself assiduously to meteorological study and was also an industrious worker in other fields of research. In 1837 he devised a self-recording pressure-plate anemometer and rain-gauge, and, in recognition of his services to this department of science, was elected a Fellow of the Royal Society in 1855. Mr. Osler was also prominently identified with the development of the crystal glass industry in Birmingham.

He was elected a Fellow of this Society, April 19, 1882.

WILLIAM VICARY was born at Newton Abbot in 1811. When a young man he went to London to gain further acquaintance with the progress of tanning, his father being a tanner at Newton. He established himself in the same business at North Tawton, but retired from it many years ago, and thereafter lived at Exeter. Having thus leisure and a competency, he was able to indulge his tastes for scientific inquiry.

A keen observer, he spent much of his time in travelling and collecting, and formed a fine assemblage of Devonian fossils which he bequeathed to the British Museum. He called attention to the fossiliferous character of some of the pebbles in the Budleigh-Salterton Pebble-Bed, and presented to the Geological Society a paper on that subject which, with Salter's accompanying description of the fossils, appeared in 1864. In the same year he was elected a Fellow of the Geological Society. He took interest also in the rocks and minerals of his native county, at one time fixing his attention on the igneous masses and at another on the Murchisonite pebbles and boulders in the Triassic conglomerates. For the purpose of aiding his examination of the fossil corals, he obtained a series of recent species. Mr. Vicary gave freely of his knowledge, and helped many geologists in other ways. Although he wrote little, he had wide scientific sympathies. Besides his geological work, he interested himself in meteorological observations and was one of the original contributors to Symons's *British Rainfall*. He died on October 22, 1903, in his 92nd year.

He was elected a Fellow of this Society on November 25, 1856.

EDWARD WOODS was born in London on April 28, 1814, and received his early education at private schools. When he was 15 he went to Bristol and began definitely to study for his future profession. His various holidays were spent in visiting the great engineering works which were then in progress. In 1834 George Stephenson relinquished the charge of the Liverpool and Manchester Railway in order to undertake the construction of the Grand Junction Railway from Warrington to Birmingham. The vacancy thus created was filled by the promotion of Mr. John Dixon from the post of Resident to that of Chief Engineer. At the same time Edward Woods was appointed one of Mr. Dixon's assistants, and took charge of the section from Liverpool to Newton-le-

Willows, a length of 15 miles, including the tunnel between Lime Street and Edge Hill, which was then in course of construction. The duties assigned to this young engineer were to superintend the works, to look after the contractors for the permanent way, set out new works, pay the contractors, police, etc., along the line, and attend the fortnightly meetings of the Board of Directors.

In 1836 Mr. Woods succeeded Mr. John Dixon as Chief Engineer to the Liverpool and Manchester Railway, with the additional charge of the mechanical department. It was thus his good fortune to have the opportunity of observing the gradual and progressive development of the railway system from its very early days.

Mr. Woods's relations with the Liverpool and Manchester Railway extended from 1834 to 1852, a period of over eighteen years; for, although the Liverpool and Manchester Railway became incorporated with the Grand Junction Railway in 1845, he remained in the service of the amalgamated companies to design and carry out the various works specially identified with the interests of the Liverpool and Manchester Railway Company, for which Acts of Parliament had been obtained.

In 1853 Mr. Woods left Liverpool, and settled in London as a Consulting Engineer on his own account. Before long he succeeded in establishing an extensive practice, and, in addition to works at home and elsewhere, his name may be specially connected with the development of the railway system in South America.

Apart from railway work, he was also engaged in the construction of buildings in Peru, for which, like some other engineers, he considered a lighter construction was preferable to one more solid, with a view to withstanding earthquakes better.

Turning to yet another branch of engineering, Mr. Woods was Consulting Engineer to the Bournemouth Gas and Water Company from its incorporation in 1863 up to the time of his death. In 1869 he became Engineer to the Monte Video Waterworks in Uruguay, projected by local capitalists and subsequently taken over by an English Company. For the Corporation of the City of London he conducted a series of observations with Messrs. Joseph Quick and Son, in connection with the Water Bill of 1884, of which the principal object was to give householders the option of taking supplies by meter.

Mr. Woods was a Member of the Institution of Civil Engineers, and filled the office of President in 1886-87.

He died on June 14, 1903, at the age of 89.

He was elected a Fellow of this Society on December 18, 1889.

APPENDIX IV.

PURCHASES DURING THE YEAR 1903.

Books.

CHAMBERS.—Educational Course. Natural Philosophy (eighth treatise), Meteorology. 8°. Edinburgh, 1849.

COXWELL, H.—My Life and Balloon Experiences. 2 vols. 8°. London, 1887-9.

YEAR-BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES OF GREAT BRITAIN AND IRELAND, 1903. 8°. 1903.

LANTERN SLIDES.

James Glaisher, F.R.S.
Glaisher's Balloon Ascents (9 slides).
Glaisher's Snow Crystals (2 slides).
Kite Observations (6 slides).

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1903.

BOOKS AND PAMPHLETS.

Presented by Societies, Institutions, etc.

AACHEN, METEOROLOGISCHE OBSERVATORIUM.—Ergebnisse der Beobachtungen am Observatorium und dessen Nebenstationen, 1902.

ADELAIDE, MARINE BOARD OF SOUTH AUSTRALIA.—Report, 1902.

ADELAIDE, OBSERVATORY.—Meteorological Observations made at Adelaide Observatory and other places in South Australia and the Northern Territory, 1899.

ANTWERP EXPEDITION ANTARCTIQUE BELGE.—Résultats du voyage S.Y. *Belgica* en 1897-99.

BANGALORE, CENTRAL OBSERVATORY.—Meteorology in Mysore, 1902.—Report on the Rainfall Registration in Mysore, 1902.

BARBADOS, COLONIAL SECRETARY'S OFFICE.—Returns of Rainfall in Barbados, 1903.

BARCELONA, OBSERVATORIO BELLOCH-LLINAS.—Hojas meteorologicas, July to Dec. 1902.

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NEWBY, H.—Photo of Tree struck by Lightning.

MACLEAR, Admiral J. P.—Photo of Lightning.

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SOPP, E. J. B.—The Frozen Mersey, February 1895 (2 photos).

APPENDIX VI.

REPORTS OF OBSERVATORIES FOR 1903.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, C.B., M.A., D.Sc., F.R.S., Astronomer-Royal.

The meteorological observations by eye, and by self-recording instruments, have been maintained as usual, and the special observations of clouds on selected days in each month have been continued at the request of the International Balloon Committee, and to render these more valuable, a nephoscope has been ordered.

The temperature of the air ranged between 87°·5 on July 11 and 23°·6 on January 16. The annual mean temperature was 49°·9, being 0°·4 above the average. The monthly mean temperatures in February and March exceeded their averages by 5°·4 and 4°·3 respectively; in April and June they were below their average values by 3°·1 and 3°·7 respectively. The sunshine recorded in the year amounted to 1445 hours out of a possible duration of 4459 hours, giving a percentage of 32 for the year. There were 73 sunless days. The total amount of sunshine was 217 hours greater than the amount recorded in 1902, and 127 hours greater than the average value for 1887-1902. Rain fell on 179 days in the year to the total amount of 35·543 ins., being 11·005 ins. greater than the average for the 50 years 1841-90, and also being the highest total registered since the commencement of the period. The rainfall in June, 6·073 ins., was the highest recorded for June, and that for the three summer months, 16·166 ins., the highest for those months in the same period (1841-1903).—*January* 30, 1904.

ROYAL OBSERVATORY, EDINBURGH.—R. Copeland, Ph.D., F.R.S.E., Astronomer-Royal for Scotland.

The meteorological observations during 1903 have been carried on by the staff of the Observatory as in former years, and no changes or additions have been made to the instruments in use. Monthly copies of all the readings and estimates have been supplied to the Secretary to the Scottish Meteorological Society, and the means have been printed in the Quarterly Reports of the Registrar-General for Scotland, along with similar returns supplied from a large number of other stations. Weekly returns of temperature and rainfall have also been furnished to the Registrar-General. At the request of the Editor of the *Scotsman* newspaper, an enlarged summary of the meteorological conditions of each week is now regularly forwarded to him for publication. It includes, in addition to the summary of wind velocities, sunshine and rainfall, published each week for the past three years, a complete set of readings of the barometer, dry and wet bulb thermometers, and the shade and exposed thermometers, with notes on the weather of each day. A summary of the mean values for each month, and for the year, are also published.

The highest reading of the barometer during the year, reduced to 32° and sea-level, was 30·641 ins. on January 30, and the lowest 28·476 ins. on February 28. The mean height of the barometer for the year was 29·812 ins., which is less than the average of the past eight years by 0·076 in.

The mean temperature of the year was 46°·4, or less than the average of eight years by 0°·4. The months in which the temperature was most conspicuously below the averages for the respective months were January, April, June, July, and December, while February was 4°·6, and March 1°·7 above the averages for these months. The maximum temperature shown by the exposed black bulb thermometer was 139°·2 on July 2, and the maximum reading in shade was 74°·6 on the same day. The minimum temperature on grass was 13°·8 on January 15, and that in shade 21°·6 on the same date.

The total number of hours of bright sunshine recorded by the Campbell-Stokes sunshine recorder throughout the year was 1291·8, being 28·9 per cent of the possible duration, compared with the average of 1352·9 hours for the past three years.

The total rainfall was 32·05 ins., or 7·39 ins. in excess of the average of the past eight years. Rain fell on 207 days, or only two days above the average.

The wettest month was October, in which 5·72 ins. were measured, or no less than 3 ins. in excess of the average for that month. January, February, March, and July were also wet, these months, with October, contributing 21·59 ins. to the total for the year.

The total number of miles of wind registered by the Robinson anemometer was 166,016, or 20,105 more than the average of the last six years. The maximum velocity in any single hour was 80 miles on February 6.

The weekly readings of the Rock thermometers on Calton Hill have been continued.—*February* 1, 1904.

NATIONAL PHYSICAL LABORATORY (KEW OBSERVATORY), RICHMOND, SURREY.—R. T. Glazebrook, D.Sc., F.R.S., Director; Charles Chree, LL.D., F.R.S., Superintendent of Observatory Department.

The several self-recording instruments have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records have been duly registered. The tabulations of the meteorological traces have been regularly made; and these, as well as copies of

the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

On the initiative of the Meteorological Office, some special cloud observations have been made with the Finemann and Strachey nephoscopes, in connection with the International scheme of balloon ascents. Extra observations have also been made, when possible, of "upper clouds," in connection with the Norwegian Polar investigations being carried out by Professor Birkeland.

Earth Thermometers.—At the request of the Meteorological Council, two Symons earth thermometers were placed in position on the lawn, at depths of 1 and 4 feet respectively, the tubes being 12 feet apart, and at a distance of 60 feet from the radiation thermometers. They have been read at 10 a.m., 4 p.m., and 10 p.m. daily since May 1, and the 10 a.m. readings are forwarded weekly to the Meteorological Office, together with the corresponding readings of the solar radiation and terrestrial radiation thermometers.

Electrograph.—This instrument worked generally in a satisfactory manner during the year. Scale value determinations were made on February 3 and 19, July 13, and November 20; and the potential of the chloride of silver battery has been tested fortnightly. Forty cells have been employed, giving about 33 volts. A series of curves—ten a month—have been selected as representative of the variations of potential on electrically "quiet" days, defined as days when irregular fluctuations of potential are fewer than usual. These curves have been tabulated, and the results appear, with the permission of the Meteorological Office, in the annual *Report*.

Atmospheric Electricity.—The comparisons of the potential, at the point where the jet from the water-dropper breaks up, and at a fixed station on the Observatory lawn, have been continued, and the observations have been taken every day when possible, excluding Sundays and wet days. The ratios of the "curve" and the "fixed station" readings have been computed for each observation, and these have thrown considerable light upon the action of the self-recording electrometer, especially with reference to the insulation problem.

Seismological Observations.—Prof. Milne's "unfelt tremor" pattern of seismograph has been maintained in regular operation throughout the year. The largest disturbances recorded took place on January 14, when the maximum amplitude exceeded 17 mm., on February 1, when the maximum was 4·5 mm., and on February 27, when the maximum amplitude was 3·5 mm.

Fog and Mist.—The observations of a series of distant objects, referred to in previous Reports, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour.

Sunshine Recorder.—The experiments referred to in last year's Report were continued throughout the year.

The mean temperature for the year was 50°·2, which is 0°·9 higher than the average for the 30 years 1871 to 1900. In the shade the maximum temperature was 83°·3 on July 11, and the minimum was 25°·0 on January 16.

The following table gives the differences of the mean monthly temperatures, from the corresponding mean values for the 30 years 1871-1900.

January	.	+2°·4	May	.	+1°·4	September	+0°·6
February	.	+5·3	June	.	−2·9	October	+3·9
March	.	+4·0	July	.	−0·6	November	+1·1
April	.	−2·3	August	.	−1·8	December	−0·3

The maximum temperature in the sun's rays (black bulb *in vacuo*) was 138° on June 28, and the minimum temperature on the grass was 12°, recorded on April 18 and on December 3. The mean percentage of bright sunshine, as registered by the Campbell-Stokes recorder, was 30 (old style) and 32 (new method)—(see *Quart. Journ. Roy. Met. Soc.*, vol. 28 p. 209), being 2 per cent below the average for the 25 years 1877-1901.

The rainfall amounted to 38·175 ins., the largest fall recorded here since exact observations began, the next largest total being 33·080 ins. in 1879. It is fully double the fall in 1901, about 80 per cent in excess of the average fall during the past 10 years, and 14·31 ins. above the average for 40 years. There were no less than 7 falls exceeding an inch, and totals of 1·79 and 1·25 ins. were recorded for June 13 and 14, this month being credited with a record of 7·205 ins. in 12 days.—*April* 22, 1904.

RADCLIFFE OBSERVATORY, OXFORD.—Arthur A. Rambaut, M.A., D.Sc., F.R.S., Radcliffe Observer.

The usual meteorological observations and automatic registers have been maintained, and the results sent regularly as heretofore to the Meteorological Office (by daily telegram), the Registrar-General, the Thames Conservancy, local newspapers, and to public and sanitary authorities upon request, and to numerous private inquirers.

During the year 1903 the five underground platinum thermometers were in daily use, and have been free from derangement throughout the year, although an incidental difficulty occurred on one day, October 31, when the great magnetic "storm" kept the galvanometer magnet in continuous disturbance, and its excursions and pulsations were watched with considerable interest for long intervals.

Curves showing the monthly variation of the temperature of the ground at different depths, compared with the air temperature (in shade) 4 feet above the surface during five years (1899-1903), were prepared, and a large diagram was exhibited at the Southport Meeting of the British Association. Contact copies of barograms during periods of exceptional atmospheric movement were also exhibited.

All the automatic instruments performed well during the year, and were subjected to the usual cleaning and careful inspection in the autumn.

The following are the chief characteristics of the weather noted at Oxford in the year 1903:—

The mean reading of the barometer was 29·688 ins., being 0·038 ins. below the mean for the preceding 48 years. The highest reading was 30·409 ins. on November 5; the lowest reading was 28·541 ins. on March 2, showing an annual range of 1·868 ins.

The mean temperature of the air was 49°·4, being 0°·5 above the mean for the preceding 75 years. The maximum temperature occurred on July 10, when 83°·7 was recorded; the minimum was 21°·2 on January 14; and the minimum on grass was 15°·2 on December 2. There is a remarkable coincidence of the above maximum with that of the previous year, when 83°·6 was reached on July 14.

The differences of the mean monthly temperatures from the corresponding means for the preceding 75 years were—

January	+2°·2	May	−0°·2	September	+0°·5
February	+5·7	June	−3·0	October	+2·5
March	+4·0	July	−1·2	November	+0·8
April	−2·4	August	−1·8	December	−0·9

Bright sunshine amounted to 1368 hours, or 92 hours below the mean for the preceding 23 years. The monthly differences from the mean were—

	hrs.		hrs.		hrs.
January	+10	May	−35	September	+ 3
February	+ 2	June	−12	October	−15
March	+ 1	July	−24	November	+4
April	− 4	August	− 9	December	−12

In striking contrast to the deficiencies of the previous 11 years, to which allusion was made in last year's report, the rainfall of 1903, 37·700 ins., was, with but one exception, far in excess of every year since 1815, and is 11·705 ins. above the mean for 88 years. The exception was the year 1852, for which a record stands of 40·42 ins. This record of 88 years' systematic observations of rainfall at one station is probably the longest continuous series in existence with any real claim to close scientific accuracy. Other and earlier records made at this Observatory also exist, but unfortunately they are discontinuous, and their quality is not comparable to those since 1815.

In 1903 the monthly deviations of rainfall from the 88 years' mean were—

	ins.		ins.		ins.
January .	+0·739	May .	+2·640	September	−0·989
February	−0·841	June .	+3·561	October .	+3·845
March .	+1·698	July .	+1·076	November	−0·770
April .	+0·631	August .	+1·066	December	−0·951

During the year the low-lying lands in the neighbourhood of the rivers Thames and Cherwell were thrice flooded; early in May, the middle of June, and again in October. Serious inconvenience and much loss resulted to local agriculturists.—*February* 19, 1904.

Rainfall in Fiji.—Mr. R. L. Holmes of Delanasau, Bua, Fiji, has sent us the following summary of his rainfall for 1903. The rain-gauge is 77 ft. above sea-level, and 1 mile from the sea.

1903.	Rainfall.	No. of Rainy Days.	Greatest Daily Fall.
	ins.		ins.
January .	7·75	16	2·02
February	3·68	12	1·06
March .	7·37	18	4·00
April .	5·25	12	1·76
May .	·78	7	·40
June .	1·75	5	1·23
July .	3·72	7	1·64
August .	·59	3	·25
September	·45	6	·17
October .	7·59	9	3·82
November	6·45	6	2·74
December	7·17	18	1·25
Year .	52·55	119	4·00

The rainfall for 1903 was the lowest registered during the previous 32 years, the next lowest being 56·87 ins. in 1878. The average for the 32 years is 95·08 ins. The greatest yearly fall was 159·51 ins. in 1871.

The rainfall for 1903 was also greatly in defect in other parts of Fiji, as will be seen from the following amounts for 1902 and 1903 in the island of Viti Levu:—

	1902.	1903.
	ins.	ins.
Vuci Maca .	113·22	61·49
Korociriciri .	106·95	75·94
Nausori .	122·79	76·35
Naitasiri .	126·78	106·78
Muanaweni .	155·49	122·01
Nadarivatu .	128·43	66·38
Ba .	85·70	57·10
Lautoka .	65·98	42·62

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 16, 1904.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

PETER ANDERSON, The Elms, Carshalton Road, Sutton;
EUGENE ANDRÉ, F.R.G.S., Port of Spain, Trinidad;
WILLIAM HENRY DOBSON, Standerton, Transvaal;
THOMAS PRICE THOMAS, Latimer Road, Llandilo; and
HANNS VISCHER, M.A., Gassol, Muri Province, Northern Nigeria,
were balloted for and duly elected Fellows of the Society.

Mr. R. H. CURTIS, F.R.Met.Soc., gave a Lecture on "WATER-VAPOUR," which was illustrated by Experiments and Lantern Slides (p. 193).

April 20, 1904.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

GEORGE BENSON CLOUGH, Bracken Knoll, Oxshott;
HENRY NOWELL FFARINGTON, The Mariebonne, Wigan;
ISIDORE GOETZ, 2 Kelfield Gardens, North Kensington; and
ALBERT EDWARD HEYER, Nursery Street, Rosebank, Cape Town,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

(1) "ONE CAUSE OF AUTUMN MISTS." By J. B. COHEN (p. 211).

(2) "THE VARIATION OF THE POPULATION OF INDIA COMPARED WITH THE VARIATION OF RAINFALL IN THE DECENNIUM 1891-1901." By W. L. DALLAS. (This paper will be printed in the next No. of the Journal.)

CORRESPONDENCE AND NOTES.

Royal Meteorological Society.—His Royal Highness the Prince of Wales has graciously consented to become Patron of the Royal Meteorological Society.

This gratifying intelligence was communicated to Commander Wilson-Barker, President of the Royal Meteorological Society, through Sir Arthur Bigge, Private Secretary to His Royal Highness.

Visit to the Kew Observatory.—On Wednesday, June 8, the members of the Council of the Royal Meteorological Society, on the invitation of Dr. R. T. Glazebrook, F.R.S., and Dr. C. Chree, F.R.S., paid a visit to the Kew Observatory. The whole of the buildings were thrown open for their inspection, and a very pleasant time was spent in listening to the descriptions of the various instruments so courteously given by the members of the staff. The visitors

were also much interested in the methods adopted and in the apparatus employed for the testing of the various instruments sent to the Kew Observatory for examination and verification.

Curious Effect of a Lightning Discharge at Stilland Farm, Sussex, January 14, 1904.—At 1.20 a.m. on January 14 a violent thunderstorm awoke the people of the farm. A poplar about 30 ft. south-east from the south-east corner of the house was struck and the limb nearest the house shattered, pieces of it being flung in all directions; one piece, passing through the branches of an oak on the opposite side of the lane, left a track as if a fragment of a shell had gone through.

Every pane of glass on the east and south sides of the house was broken, the pieces, I was told, falling both inboard and outboard; the door was forced open inwards, drawing a slight hasp. The iron rain-water gutter under the roof at the south-east corner and the rain-water pipe were broken in places where there were joints or junctions. Within the house an ornamental moulding of wood running round the south-east room on the ground floor was cracked, and the paint which covered a gold-leaf strip was thrown off; some wood in the farther corner of the room, near a bell-wire, was also cracked.

An examination of some of the débris around the tree showed that the wood at the junction of the broken-off limb was rotten, though higher up the limb appeared sound. It seems to me that water had lodged at the junction of the limbs, perhaps in the rotten wood, and that the lightning discharge converted this into steam with explosive rapidity, and in fact that the windows of the house were broken by the concussion.

The same thunderstorm is referred to in *Symons's Meteorological Magazine* for January, p. 9.—J. P. MACLEAR.

International Cloud Atlas.—We have received a letter on this subject from Dr. Hergesell, of which the following is a translation:—

Dear Sir and Colleague,—The Cloud Observations of the International Committee for scientific aerostation have given occasion for the expression by a great number of participators in the ascents of a desire to possess more copies of the *International Cloud Atlas*. The first edition is out of print, so that compliance with the request is impossible unless a new edition of that excellent publication is brought out.

Monsieur Teisserenc de Bort, to whom, in conjunction with Messrs. H. H Hildebrandsson and A. Riggenbach, the publication of the *Atlas* had been entrusted, and who had brought out the first edition, has proposed to bring out a new edition of the work if an interest is manifested to justify the measure. He wishes to learn the approximate number of copies desired.

We therefore request you to let me know as soon as possible, but without binding yourself, how many copies you would want for your Institution or your stations in future years. The *Atlas* can be delivered at the very reduced rate of about 8 francs.

Will you also be so kind as to let us know what minor improvements in the *Atlas* you would propose, based on your continuous employment of the International Classification. We cannot entertain the idea of a change in principle, but only of practical modifications, and of additions, based on the principles of classification which have already been adopted. The proposals will be reviewed by M. Teisserenc de Bort, grouped together, and finally submitted by him to a committee of competent meteorologists.

The intention of M. Teisserenc de Bort is worthy of the very active sympathy of our Committee, and we therefore beg you to support us in the way indicated.

I beg you, Sir, to accept the expression of my distinguished regard.—The President of the International Committee for Aerostation, HERGESELL, Strassburg, April 29, 1904.

Transparency of the Atmosphere.—Prof. Cleveland Abbe, the editor of the U.S. *Monthly Weather Review*, has sent the following letter on this subject:—

Sir,—You may have noticed that records have been published by Messrs. C. Dufour of Lausanne, H. H. Kimball, S. P. Langley, and C. G. Abbot of Washington, Max Wolf of Heidelberg, and Gorczynski of Warsaw, showing that an appreciable general diminution of the transparency of the earth's atmosphere took place sometime during the year 1902, but disappeared at some time during 1903. This is an important matter, and may possibly be made the basis of an explanation of other meteorological phenomena. I beg to ask whether you have any records that will assist in defining the dates of beginning and ending, and the extent of this change in transparency. Such records may consist of photometric or photographic observations of the brightness of the stars; changes in the solar or stellar spectra; unusual prevalence of halos, large Bishop's ring, or haze; observations of heat received from the sun, as made with actinometers or pyrheliometers; observations of the polarisation of the blue sky light, and of scintillation of the stars.

Undoubtedly this diminution and increase of transparency began and ended at different dates in different places, as the phenomena spread gradually over the world during the years 1902 and 1903; additional records are therefore desired in order to trace its progress. Will you not kindly examine your records from this point of view, and send me the result for publication in a general article on this subject.—Very respectfully, CLEVELAND ABBE, Professor and Editor, Weather Bureau, Washington, U.S.A., April 15, 1904.

Observations at Masaba, Equatorial Africa.—The Rev. W. A. Crabtree, of the Church Missionary Society, has regularly forwarded to the Royal Meteorological Society during last year the climatological observations made by him at Masaba, Mount Elgon, Kavirondo, East Equatorial Africa. The monthly results are as follows:—

1903.	Temperature.							Relative Humidity.	Rain.	
	Means.					Extremes.			Amount.	No. of Days.
	7.30 a.m	Min.	Max.	Range.	Mean.	Min.	Max.			
	°	°	°	°	°	°	°	%	ins.	
January .	68·5	63·0	82·8	19·8	72·9	58·1	88·3	78	7·130	16
February .	69·9	63·5	84·6	21·1	74·1	60·9	90·7	70	1·890	7
March . .	70·4	63·3	84·0	20·7	73·7	61·5	89·2	78	3·520	16
April . .	70·0	62·6	82·1	19·5	72·3	60·4	90·1	77	5·650	22
May . .	68·7	62·8	79·7	16·9	71·3	60·4	84·1	83	7·900	25
June . .	65·7	61·0	77·2	16·2	69·1	58·4	79·8	86	9·825	27
July . .	64·9	60·9	76·9	16·0	68·9	58·2	80·2	86	5·235	25
August . .	65·2	59·8	78·7	18·9	69·2	56·7	83·8	82	1·350	18
September .	66·4	59·8	79·3	19·5	69·6	57·8	84·1	83	5·715	26
October .	66·6	60·1	80·6	20·5	70·3	57·5	84·6	79	2·560	17
November .	72·2	60·1	84·3	24·2	72·2	53·8	86·8	64	1·900	8
December .	72·2	60·7	85·1	24·4	72·9	57·2	90·5	65	1·460	9
Year . .	68·4	61·5	81·3	19·8	71·4	53·8	90·7	77·6	54·135	216

The height of the station is 4300 ft. above sea-level, and the observations are taken at 7.30 a.m.

The highest temperature during the year was 90°·7 on February 21, and the lowest 53°·8 on November 7. The heaviest rainfall was 3·92 ins. on June 14, which fell in 15 hours. Slight seismic shocks occurred on May 25 and 29.

Meteorology of Jamaica.—The Institute of Jamaica has published a pamphlet by Mr. Maxwell Hall entitled *The Meteorology of Jamaica*. This contains a description of the various instruments used in making meteorological observations, and gives instructions in observing the humidity, rainfall, clouds, etc. Tables for the reduction of observations are also given. The following particulars may be of interest to our readers:—

AVERAGE MONTHLY TEMPERATURES AT KINGSTOWN, 1881–1898.

MONTH.	Mean.	7 a.m.	3 p.m.	Max.	Min.
	°	°	°	°	°
January . .	75·8	68·9	83·1	86·1	67·0
February . .	75·7	69·4	82·7	85·6	67·0
March . .	76·4	71·3	82·8	85·6	67·8
April . .	78·2	74·9	83·3	86·3	70·0
May . .	79·9	78·1	83·7	87·0	72·5
June . .	31·1	79·1	85·2	88·2	73·7
July . .	81·6	78·7	86·4	89·5	73·4
August . .	81·0	77·6	85·7	89·5	73·4
September .	80·7	76·9	85·2	89·2	73·5
October . .	79·3	75·6	84·5	88·0	72·4
November .	78·6	73·4	84·3	87·9	70·7
December .	76·9	70·7	83·3	86·7	68·4
Year . .	78·8	74·6	84·2	87·5	70·8

The highest temperature recorded during the period was 96°·7 on August 20, 1891, and the lowest 56°·7 on December 4, 1887.

The diurnal range of relative humidity is rather large, being 81 per cent at 7 a.m., 68 per cent at 3 p.m., and 85 per cent at 11 p.m.

There are about 200 rain gauges observed in Jamaica, but they are not very uniformly distributed over the island. The average monthly rainfall for the whole island is—

January . .	3·79 ins.	May . . .	9·56 ins.	September . .	7·12 ins.
February . .	2·62 ,,	June . . .	6·11 ,,	October . .	10·37 ,,
March . .	2·86 ,,	July . . .	4·76 ,,	November . .	6·50 ,,
April . . .	4·20 ,,	August . .	6·61 ,,	December . .	5·53 ,,

The average annual rainfall is about 70 ins. Far more rain falls in the north-eastern division than in any other; then follows the west-central division, then the northern, and lastly the southern. But the rainfall varies greatly over each division. In the north-eastern division the greatest rainfall occurs in the valley of the Rio Grande, at the base of the Blue Mountains. A rain gauge has been kept at Moore Town since February 1896, and it shows an annual rainfall of about 248 ins. At Blue Mountain Peek the annual rainfall is 175 ins.; and at twelve other stations in the north-eastern division, where registers have been kept for seven years and more, the annual rainfall exceeds 100 ins.

Deep Earth Temperatures at Harestock and Southport, 1899-1903.—In the *Quarterly Journal*, vol. 25, p. 271, we gave the monthly mean temperatures of the soil at Harestock at 10 feet, 20 feet, and 30 feet, and at Southport at 10 feet, for the six years 1893-1898. We now give the monthly means for

the next five years, viz. 1899-1903, for the same depths, with the addition of those at 70 feet at Harestock and at 20 feet at Southport.

Harestock, near Winchester, is on the Downs, at a height of 300 feet above sea-level. The observations are taken daily at 9 a.m. by Col. H. S. Knight.

At Southport the soil is sand, and the height is 21 feet above sea-level. The observations are taken daily under the superintendence of Mr. J. Baxendell.

MONTHLY MEAN TEMPERATURES OF THE SOIL AT HARESTOCK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
10 Ft	°	°	°	°	°	°	°	°	°	°	°	°	°
1899	51·02	49·70	48·62	47·88	48·00	48·94	50·63	52·55	54·03	54·47	53·68	52·61	51·01
1900	50·79	49·17	47·80	47·14	47·34	48·38	49·99	51·84	53·14	53·57	53·21	52·21	50·38
1901	50·96	49·48	48·06	47·23	47·35	48·52	50·22	52·10	53·42	53·87	53·41	51·88	50·54
1902	50·09	48·84	47·50	47·17	47·45	48·23	49·77	51·50	52·67	53·11	52·67	51·58	50·05
1903	50·17	48·92	48·23	47·92	48·00	48·83	50·14	51·70	52·86	53·35	53·25	52·04	50·45
20 Ft.													
1899	51·54	51·43	51·19	50·86	50·51	50·27	50·20	50·37	50·77	51·27	51·72	51·96	51·01
1900	51·99	51·78	51·39	50·92	50·08	49·75	49·65	49·78	50·14	50·59	51·00	51·26	50·69
1901	51·31	51·20	50·91	50·48	50·07	49·77	49·69	49·86	50·23	50·71	51·15	51·40	50·57
1902	51·40	51·17	50·81	50·36	49·95	49·68	49·58	49·72	50·05	50·46	50·85	51·08	50·43
1903	51·10	50·94	50·63	50·27	49·96	49·75	49·71	49·86	50·16	50·56	50·96	51·24	50·43
30 Ft.													
1899	50·29	50·37	50·42	50·43	50·38	50·30	50·20	50·13	50·10	50·13	50·22	50·36	50·28
1900	50·51	50·61	50·66	50·92	50·81	50·67	50·53	50·43	50·35	50·36	50·44	50·82	50·59
1901	50·90	50·98	51·00	51·01	50·97	50·87	50·75	50·64	50·61	50·63	50·72	50·82	50·83
1902	50·95	51·03	51·09	51·07	50·99	50·88	50·78	50·70	50·65	50·65	50·72	50·81	50·86
1903	50·92	51·00	51·01	51·00	50·92	50·85	50·75	50·71	50·68	50·71	50·71	50·79	50·84
70 Ft.													
1899	49·81	49·82	49·82	49·82	49·83	49·83	49·83	49·84	49·85	49·85	49·86	49·87	49·84
1900	49·88	49·93	49·90	49·90	49·92	49·93	49·95	49·96	49·98	49·99	49·98	49·96	49·94
1901	49·96	49·95	49·96	49·97	49·97	49·98	49·98	49·99	50·07	50·05	50·05	50·05	50·00
1902	50·07	50·07	50·07	50·08	50·09	50·09	50·10	50·10	50·10	50·11	50·12	50·13	50·09
1903	50·13	50·13	50·14	50·15	50·15	50·15	50·16	50·17	50·18	50·19	50·17	50·17	50·16

At 10 feet the maximum takes place in October, and the minimum in April.

At 20 feet the extremes take place about three months later than at 10 feet, the maximum being in December or January, and the minimum in July.

At 30 feet the extremes occur two or three months later than at 20 feet, the maximum taking place in March or April, and the minimum in September.

At 70 feet the temperature is very nearly constant, the mean annual range being only 0°·08. The temperature has been increasing steadily but slowly throughout the period.

MONTHLY MEAN TEMPERATURES OF THE SOIL AT SOUTHPORT.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
10 Ft.	°	°	°	°	°	°	°	°	°	°	°	°	°
1899	48·22	45·88	45·05	45·78	47·79	50·63	53·78	55·73	56·43	54·79	52·07	49·86	50·50
1900	46·41	44·28	43·16	44·17	46·98	49·98	53·03	55·53	56·22	55·20	52·87	50·08	49·83
1901	47·86	45·79	44·79	45·14	47·55	50·60	53·41	55·68	55·98	55·01	52·37	49·10	50·27
1902	45·96	44·47	43·59	45·08	47·09	49·76	52·93	54·71	55·23	53·99	51·93	48·74	49·46
1903	46·40	45·01	45·24	46·05	47·39	50·70	53·40	55·40	55·80	54·70	52·10	48·60	50·07
20 Ft.													
1899	50·75	49·91	49·15	48·60	48·42	48·65	49·32	50·20	50·99	51·49	51·51	51·17	50·01
1900	50·51	49·45	48·48	47·84	47·72	48·08	48·77	49·67	50·65	51·29	51·49	51·27	49·60
1901	50·66	49·96	49·17	48·55	48·29	48·55	49·16	49·91	50·72	51·22	51·36	51·05	49·88
1902	50·27	49·37	48·58	48·02	47·92	48·17	48·82	49·69	50·45	50·95	51·04	50·76	49·50
1903	50·03	49·24	48·64	48·20	48·16	48·41	49·03	49·81	50·61	51·28	51·49	51·12	49·67

At Southport the thermometers are subject to greater changes and the extremes take place earlier than at Harestock. This is no doubt due largely to the nature of the soil, and also to the height above sea-level.

At 10 feet the maximum occurs in September and the minimum in March or February.

At 20 feet the extremes are two months later than at 10 feet, the maximum occurring in November and the minimum in May.

Temperature of the Upper Air over Berlin.—Dr. R. Assmann has just issued a pamphlet entitled "*The Temperature of the Air over Berlin*, from October 1, 1902, until December 31, 1903, as shown from the daily ascents carried on at the Aeronautical Observatory of the Royal Meteorological Institute of Prussia." This is a valuable and interesting contribution to the literature of the conditions of the upper air, and as it is in English we reprint it, and only regret that we cannot reproduce the striking diagram (nearly 10 ft. long) which accompanies it. We give in brackets the equivalent English measures and temperatures. Dr. Assmann says :—

There are four methods employed by modern aeronautics for scientific purposes :

1. Ascents of free balloons, carrying one or more observers. After the famous ascents of James Glaisher, in the years 1862-66, it is only since 1891 that they have been seriously taken up again at Berlin, and since then a large number of ascents have been undertaken with improved instruments, especially with Assmann's aspirated psychrometer, up to the greatest altitudes ever reached (10,800 m. [35,434 ft.], Berson and Süring, on July 31, 1901).

2. Ascents of smaller balloons carrying self-registering instruments, after the example of Hermite and Besançon at Paris, called *ballons-sondes*—a method tested, above all, by Teisserenc de Bort at Paris by hundreds of ascents. Instead of balloons of 40-100 cubic metres, in fabric or paper, as employed elsewhere, at the Observatory we make use of small elastic indiarubber balloons holding but 2-3 cubic metres, which, increasing in volume with the height, soar up with growing velocity and finally burst, without reaching equilibrium, when a parachute brings the apparatus safely to the ground. An ascent up to 20,000 m. [65,618 ft.] takes but an hour's time or little more, and so does the descent; thus the indiarubber balloon hardly ever covers a distance of more than 50-70 km. [31-43 miles] in its flight.

3. The lifting of registering instruments by means of kites. The introduction of kites into the investigation of the higher strata is due to Mr. Abbot Lawrence Rotch, Director of the Blue Hill Observatory, near Cambridge, Mass., U.S.A., whose methods are employed in the whole civilised world, and therefore at this Observatory. The ascents are chiefly made by means of the Hargrave kite, with the improvements of Mr. Helm Clayton of the Blue Hill Observatory, who applied to the kite curved frontal surfaces (Lilienthal's curved surfaces).

4. In case of the wind being too weak to lift kites (below 5-6 mps.) [11 to 13 miles per hour], the kite balloon of Sigsfeld-Parseval (capacity 68 m^3 hydrogen) is used, and enables us to reach heights up to 2500 m. [8202 ft.].

The Aeronautical Observatory of the Royal Meteorological Institute of Prussia established in the year 1899, near the shooting camp of Tegel, in very modest dimensions, avails itself of all the four methods above mentioned. In spite of its unfavourable situation in the midst of extensive forests and the perils and hindrances resulting from the vicinity of Berlin with its electric street car lines as well as the neighbourhood of the military grounds (shooting camp and barracks of the balloon division), since August 1902 there have been made daily ascents with kites or kite-balloons, without any regard to the

weather. The results thereof have been regularly published, through the medium of the Berlin Weather Bureau, in the *Official Gazette* of the same day and several of the more important evening papers of the Metropolis, as well as in the daily weather charts of the "Deutsche Seewarte" at Hamburg and of the Berlin Weather Bureau.

The regular ascents are made in the forenoons, the publication of the results in the charts making it necessary to get through with the experiments by 12 o'clock and with the readings by 12.30. But ascents are made also at other times, and on the days of the "International Ascents" generally the whole night is being worked through. The readings are given for fixed intervals of height. Thus there are published air temperature, relative humidity, direction and velocity of wind for the base (40 m. [131 ft.] above sea-level), for 200 m. [656 ft.], 500 m. [1640 ft.], 1000 m. [3281 ft.], 1500 m. [4921 ft.], etc., a few words about anomalies in the vertical distribution of these elements and the limits of the cloud strata being added.

In higher ascents some of the above-given intervals are omitted in the publication for want of space.

The publication in the *Official Gazette* runs as follows:—

Readings at the Aeronautical Observatory of the Royal Meteorological Institute, published by the Berlin Weather Bureau.

KITE ASCENT OF DECEMBER 4, 1903, 8.30 TO 11 A.M.

Height above Sea-level	40 m. [131 ft.]	500 m. [1640 ft.]	1000 m. [3280 ft.]	2000 m. [6562 ft.]	3000 m. [9843 ft.]	3540 m. [11,615 ft.]
Temperature (C)	−4°·8	−2°·7	−5°·4	−6°·2	−11°·8	−14°·1
Temperature [F]	[23°·4]	[27°·1]	[22°·3]	[20°·8]	[10°·8]	[6°·6]
Relative Humidity (%)	86	76	70	24	1	1
Direction of Wind	SE.	S.	S.	SSW.	SSW.	SSW.
Velocity of Wind—						
Metres per second	4·2	10·0	11·0	14·0	17·2	16·0
[Miles per hour]	[9]	[22]	[25]	[31]	[39]	[36]

Cloudless.—The temperature increased from the ground up to 500 m. [1640 ft.], and again between 1075 m. [3527 ft.] and 1600 m. [5249 ft.], from −6°·1 C. [21°·0 F.] to 5°·2 C. [41°·4 F.].

To avoid a misrepresentation of the true vertical distribution of the temperature in the lower strata caused by the rapid change to which the air temperature near the ground is subject in the morning hours, there is given for the "base" (40 m.) [131 ft.] the temperature of the moment corresponding to that when the reading for the next interval of height (200 or 500 m.) [656 or 1640 ft.] is taken.

The subsequent graphical statement is founded on such readings, and has been published regularly in the meteorological monthly *Das Wetter*.

The horizontal lines represent the heights in intervals of 100 metres [328 ft.], the thin verticals giving the limits of two consecutive days. The thicker verticals correspond to the heights reached and the day-time of the ascents, the temperature at the different heights being represented as strictly simultaneous, although this fact is not, and naturally cannot be, the case. Still, in view of the comparatively short duration of the ascents when at the greater elevations, this inexactitude is but a trifling one, considering the small effect of the daily range in those heights. Equal temperatures were joined by isothermal lines drawn for every 2° C. [3°·6 F.], the intervening isotherms being added when necessary. Real readings are represented by full isotherms, inter- or extra-polated values by dotted lines. Additional observations, taken by means of free or self-registering balloons, are represented by dotted verticals, up to a

limit at 5500 m. [18,045 ft.] drawn by the size of the diagram. The lower and, where attained, also the upper surfaces of clouds are indicated by a W (lower) or $\overline{W}$ (upper surface) (W = **Wolken**, German for clouds), and occasionally by $\overline{cu}$ (cumuli).

The diagram representing the air temperature above Berlin during a period of fifteen months (October 1, 1902, till December 31, 1903), and showing only in its first three months a few gaps (caused by intervening Sundays and holidays; since 1903 these days were also included in the regular work of the Observatory), appears to be so far the first, and unique of its sort. It establishes a clear picture of the change of temperature from day to day at the different heights, and shows the occasionally quite enormous oscillations therein. Likewise it demonstrates the unexpectedly frequent formation of thermal belts and inversions in their intensity and duration, as well as the invasion of cold or hot "waves." It may be added that the daily range of temperature at the base has not been taken into account, since this would have often led to an illegible accumulation of the isothermal lines.

In order to facilitate the study of the distribution and change of temperature, all values lying above the freezing-point have been shown in the plates by a red ground-colouring, the limit thereof corresponding to the isotherm of 0° C. [32° F.]. It will be found at an elevation of some 2200 m. [7218 ft.] on October 1, 1902, at but 450 m. [1476 ft.] on the 2nd, and on the ground on October 4, though the temperature lay above the freezing-point up to 550 m. [1804 ft.]. The cold wave (current), which had descended from above and reached the ground on the 4th, prevailed yet on the 6th at 500 m. [1640 ft.], but it has grown warmer above and beneath it: the 0° C. [32° F.] isotherm rises on the 7th to 2700 m. [8858 ft.], and sinks until the 20th in a series of oscillations to 1200 m. [3937 ft.], when it rapidly soars up to 2600 m. [8530 ft.], and quickly descends again to 1250 m. [4101 ft.] until the 22nd. Until the 25th it rises more slowly to 2000 m. [6561 ft.], sinks till the 28th to 1200 m. [3937 ft.], to wind the month up by two rapid oscillations between 2700 and 1050 m. [8858 and 3445 ft.] with some thermal discontinuities in the lower strata. Such are to be seen more particularly in the first part of November, forming as it were "islands" of colder or warmer air, the freezing-point line keeping high all the while (2800 to 2000 m.) [9187 to 6569 ft.]. On the 14th there commences a frost period on the ground, while it yet continues to be warmer in 500 to 1000 m. [1640 to 3281 ft.]. The prolonged period of frost, holding until December 15, shows only two breaks, from 21st till 27th and on the 29th of November, when the 0° C. [32° F.] isotherm ascends to 1000 m. [3281 ft.]; but on December 12 there appears already in the heights an intense warm wave, with temperatures above 0° C. [32° F.] (up to + 4° C. [39°·2 F.] and more), while on the ground there are found 8 degrees of frost C. [17°·6 F.]. The warm wave reaches the ground on the 16th, and a similar process is seen on December 22 and 23, with analogous formation of strata. Until January 12 the 0° C. [32° F.] line remains comparatively high (up to 2500 m.) [8202 ft.], though with repeated considerable oscillations; but it then sinks to the ground, to remain there until the 24th. On the 19th and 20th we find between 1000 and 1500 m. [3281 and 4921 ft.] a pronounced inversion: −10° C. [14° F.] below, 0° C. [32° F.] above. Then follows an extraordinary rise of temperature the heights from the 24th till the 27th (+ 8° at 1500 m.) [46°·4 at 4921 ft.], the 0° C. [32° F.] line rises up to 3100 m. [10,171 ft.], and this again is followed by rapid cooling off, formation of thermal strata (February 1-10), and cold waves on 14th-17th. From the 18th-19th the 0° line ascends from the ground to 2500 m. [8202 ft.]; at a height of 1400 m. [4593 ft.] there was a temperature of − 12° C. [10°·4 F.] on the 16th, and one of + 6° C. [42°·8 F.] on the 20th. The further course of our line till March 5 shows rapid and considerable oscilla-

tions between 500 and 2500 m. [1640 and 8202 ft.], after which it slowly descends to the ground, touching it for the last time in the season on the 11th and 13th. Until March 23 it again keeps rising, accompanied by manifold thermal changes, and attains 2750 m. [9022 ft.]. A cold wave brings it down again on April 2-6 to 500 m. [1640 ft.]. On April 4 the isothermal lines below 0° C. [32° F.] are bent up rapidly and very steeply, but the 0° C. [32° F.] does not take part in this to any degree. With numerous short changes, this latter keeps comparatively low till April 21, from 200 to 700 m. [656 to 2297 ft.], and ascends, after a rapid oscillation on the 22-25th, until the end of the month slowly but continually, to attain, on May 3 and 4, 3200 m. [10,499 ft.]. The "cold saints" of May 10-13 and again the 19th show a fall till 1300 and 900 m. [4265 and 2953 ft.]; the 15th and 16th, an interesting inversion at 2000-2600 m. [6562 to 8530 ft.]. From May 19 there begins a considerable rise till 3200 m. [10,499 ft.], followed only on June 3 by a descent to 2250 m. [7382 ft.]. In June the mean elevation of the 0° C. [32° F.] line keeps high, between 3500 and 2200 [11,483 and 7218 ft.], and likewise in July and August, showing now stronger shifts of height between 2000 and 3000 m. [6562 and 9843 ft.] in nearly regular ten daily periods. After a sudden descent of cold air down to 1500 m. [4921 ft.] on August 30, there follows an extraordinary rise of the 0° C. [32° F.] line, reaching its annual extreme on September 3 with 5600 m. [18,373 ft.], which again was followed by a similarly rapid fall to 2800 m. [9187 ft.] till the 8th, and to 1150 m. [3773 ft.] till the 12th. After that came considerable rise to 3500 m. [11,808 ft.] 18th till 20th, and up to 4000 m. [13,124 ft.] on the month's last day, followed by a quick descent until the 3rd of October, and a slow rise to 2800 m. [9187 ft.] till the 9th. In a series of considerable oscillations between 2900 and 200 m. (9515 and 656 ft.) combined with frequent inversions, our line sinks by the end of November and beginning of December to the ground. In December 1903 there prevails formation of thermal strata up to 2000 m. [6562 ft.], except on the days of 7th-11th.

We beg to present this first essay of a continuous study of temperature in the free atmosphere to our colleagues and to all friends of scientific aeronautics, and in doing so cannot forbear to remark that it has been the result of hard work, done in all sorts of wind and weather—the execution of the ascents remaining chiefly in the hands of Prof. Berson and Dr. Elias, besides the Director and all the other members of the Observatory.

Temperature of the Air at 6 miles above the Earth.—Hofrath Dr. Julius Hann laid before the Vienna Academy, on April 21, a paper on the deduction of temperature up to 10 kilometres (6 miles) altitude, according to the results of the International Balloon Ascents.

Dr. Hann was induced to see if the temperature observations from the balloon ascents, so far as yet published, allow of a calculation of the annual range of temperature with an approach to accuracy.

He employed both the manned and unmanned ascents. He found over 150 sets of temperature observations up to 7 kilometres (4 miles), and above that level up to 10 kilometres (6 miles)—in all, about 125. In this connection several ascents on the same day and at the same locality were only calculated once (and used as means).

The result was that the monthly means of temperature up to 1, 2, 3, and up to 10 kilometres, were too seriously affected by the weather conditions of the day of ascent to give any reasonable, trustworthy annual range. On the other hand, this is not quite true; for the *temperature differences* for intervals of a kilometre in altitude for the annual range come out very clearly in these figures. The monthly values of temperature differences for altitude intervals

of $1-3+3-5+5-7$ and $7-9$ are represented by periodical series, and the annual range is calculated from them.

The results of these calculations were somewhat surprising. In the stratum between the altitude of 1 to 3 kilometres (0·6 to 1·2 mile), the annual range agrees very well with that determined from the observations at fixed mountain stations. The phase epochs are just the same, but the amplitude is less in the free atmosphere.

Sonnblick—Gastein.

$$11°{\cdot}47 \text{ C. } (20°{\cdot}7 \text{ F.}) + 2{\cdot}67 \sin (296° + x) + 0{\cdot}75 \sin (296 + 2x).$$

Free Atmosphere.

$$9°{\cdot}37 \text{ C. } (16°{\cdot}9 \text{ F.}) + 2{\cdot}04 \sin (300° + x) + 0{\cdot}37 \sin (244 + 2x).$$

This is the annual range of temperature differences up to the level of 1 to 3 kilometres (0·5 to 1·2 mile). The most rapid decrease in both cases occurs in May and June.

On the other hand, in the intervals between 3 and 5 kilometres (1·9 to 3·1 miles) and between 5 and 7 kilometres (3·1 to 4·4 miles), the most rapid decrease of temperature occurs in March and April; and, quite unexpectedly, in the interval from 7 to 9 kilometres (4·4 to 5·6 miles) it occurs in summer, at the beginning of July. The amplitudes, at first, decrease with altitude, and then from 7 to 9 kilometres (4·4 to 5·6 miles) they increase considerably.

As, however, Mons. Teisserenc de Bort has published the temperatures from 581 ascents of *ballons sondes* (unmanned balloons) as means for the seasons, these may be employed to check the foregoing results, as the author has already shown that it is quite possible to determine, with sufficient accuracy, the temperature curve for the whole year from the means for the seasons. The results given above receive complete confirmation, as the temperatures published by Mons. Teisserenc de Bort show that in the stratum from 9 to 11 kilometres (5·6 to 6·8 miles) the maximum temperature decrease comes in the autumn, while the minimum decrease occurs in spring. The first term of the sine series gives for the approximate epoch of the most rapid decrease of temperature at the strata of—

Altitude .	1 to 3 (0·6 to 1·9)	3 to 5 (1·9 to 3·1)	5 to 7 (3·1 to 4·4)	7 to 9 (4·4 to 5·6)	9 to 11 km. (5·6 to 6·8) miles.
Max. .	May 15	Feb. 14	Jan. 27	July 28	Sept. 15

As the temperature differences which have been mentioned, taken from 17 years' monthly means from the Sonnblick, Dr. Hann has deduced monthly means of temperature for altitudes of 5, 7, and 9 kilometres (3·1, 4·4, and 5·6 miles), but he does not attach much weight to these. It is remarkable that the annual amplitude does not decrease but increase with height, and the same is shown by the differences, summer and winter, in the means of Mons. Teisserenc de Bort:—

Altitude . .	3 kilometres (1·9 mile)	5 kilometres (3·1 miles)	7 kilometres (4·4 miles)	9 kilometres (5·6 miles)
Yearly Variation .	C. 14°·5	16°·1	16°·7	14°·8
	F. 26°·1	29°·0	30°·1	26°·6
Summer—Winter	C. 9°·9	10°·5	11°·3	9°·5
	F. 17°·8	18°·9	20°·3	17°·1

The values of the decrease of temperature for 100 metres (328 feet) show a complete agreement (1) from the first balloon ascents at Berlin; (2) from the international ascents, calculated by the author; and (3) from the 581 balloon ascents in Paris. The author then puts all the results from manned ascents

together, and these agree very well with those of the self-registering apparatus taken by themselves.

Dr. Hann then endeavours from his materials to deduce the temperature decrease with altitude for anticyclonic and cyclonic areas for the winter half-year and the summer half-year, calculated separately. For this he could use ten or twelve of each, so about forty cases on the whole. The results agree with those determined by him from the Sonnblick observations up to the level of 3 kilometres (1·9 mile), and agree with those stated by Mons. Teisserenc de Bort for higher strata in general terms, but without giving numerical data.

The author finds the following values :—

TEMPERATURE DECREASE FOR 100 METRES (328 FEET).

		Anticyclones.		Cyclones.	
		Winter Half-Year.	Year.	Winter Half-Year.	Year.
0 to 5 kilometres	C.	0°·35	0°·40	0°·52	0°·53
0 to 3·1 miles	F.	0·65	0·72	0·93	0·95
5 to 10 kilometres	C.	0·73	0·71	0·56	0·62
3·1 to 6·2 miles	F.	1·32	1·28	1·00	1·12
0 to 10 kilometres	C.	0·55	0·55	0·54	0·57
0 to 6·2 miles	F.	0·97	0·98	0·97	1·02

The decrease of temperature with altitude in the lower strata of the atmosphere is slower in anticyclones than in cyclones, but at the upper levels this relation is reversed. Mons. Teisserenc de Bort was the first to find this out, but, as has been said, without publishing the figures for this statement.

The lowest temperatures at very high levels are found in anticyclones. On December 5, 1901, two *ballons sondes* over Paris, over an extensive anticyclone, agreed in giving a temperature of − 73° C. (− 99·4 F.) at the level of from 12 to 13 kilometres (7·5 to 8·1 miles). The decrease of temperature over Central Europe at the time was only 0°·27 C. (0°·48 F.) up to 5 kilometres (3·1 miles), only 0°·73 C. (1°·32 F.) from 5 to 10 kilometres (3·1 to 6·2 miles), and about 1° C. (1°·8 F.) for 100 metres (328 feet) from 10 to 12 kilometres (6·2 to 7·5 miles).

As for the mean difference of temperature between anticyclones and cyclones, Dr. Hann obtained the following figures from the observations he discussed. These can only lay claim to provisionary value, while the signs may be taken as reasonably correct.

TEMPERATURE DIFFERENCES—MAXIMUM-MINIMUM LEVEL.

Altitude						
km.		0 to 1	1 to 2	2 to 3	3 to 4	4 to 5
mile		0 to 0·6	0·6 to 1·2	1·2 to 1·9	1·9 to 2·5	2·5 to 3·1
Winter Half-Year	C.	1°·3	3°·0	5°·0	4°·5	4°·5
	F.	2°·3	5°·4	9°·0	8°·1	8°·1
Year	C.	(0°·3)	3°·3	4°·6	4°·8	5°·1
	F.	(0°·5)	5°·9	8°·3	8°·6	9°·2
km.		5 to 6	6 to 7	7 to 8	8 to 9	9 to 10
mile		3·1 to 3·7	3·7 to 4·4	4·4 to 5·0	5·0 to 5·6	5·6 to 6·2
Winter Half-Year	C.	4°·0	3°·0	1°·6	− 0°·8	− 3°·3
	F.	7°·2	5°·4	2°·9	− 1°·4	− 5°·9
Year	C.	5°·0	4°·4	3°·5	2°·1	0°·6
	F.	9°·0	7°·9	6°·3	3°·8	1°·1

The figures for the winter half-year are the most trustworthy. At the ground level and above 8 kilometres the minima are warmer; at the intermediate strata the maxima. The excess of temperature in the anticyclones attains its greatest value of about 5° at the level of from 2 to 3 kilometres. The author had obtained a similar result from the Sonnblick observations. The mean for the stratum from 1 to 10 kilometres should, from the foregoing,

give an excess of temperature for the anticyclones, but that remains questionable until Teisserenc de Bort has published his figures.

Weather Notes in Samuel Pepys' Diary, 1659-1669.—In this famous Diary, the author, in writing the historical portions, was careful not to omit his remarks on the weather—and in this, I think, he is entitled to rank as one of the first of British meteorologists, although he knew nothing of the instruments employed therein to-day. His remarks upon the weather between the years 1659 and 1669 give us a fair insight of British climatology for that period, after which he was compelled to give up from loss of eyesight. I have carefully selected and arranged the notes to their respective dates.—R. SHEWARD, Eastbourne.

January.

1659.—16th. Cold, frosty, windy day.

1661.—21st. It's strange what weather we have had this winter—no frost at all; the rose bushes are in full leaf; such a time never before known.

1662.—15th. Parliament ordered this to be a Fast Day, to pray for more seasonable weather, it having been as though it was the middle of May or June, which all men say do threaten a plague.

1665.—6th. One of the coldest days, all men do say, ever known in England.

1666.—10th. News arrived of great storms on the sea. Our fleet scattered; three got back to Plymouth with loss of masts.

——.—24th. My Lord and I to Deptford. We had to walk back, the wind so very furious we durst not return by water, and it was dangerous to walk the streets, from the bricks and tiles falling from the houses; whole houses were blown down. The pales on both sides of London Bridge blown down. Great sight to see how the ships were blown about, and one quite overturned.

1667.—2nd. My wife, with Mrs. Pen, took a walk in the fields to frost-bite themselves.

——.—9th. To Whitehall, the way being horribly bad on the breaking up of the frost.

February.

1659.—27th. Went to Epping; raining all the way.

1662.—25th. In the late great wind, five large trees were blown down. In the Forest of Deane about 1000 oaks and as many beeches were blown down in one walk.

——.—27th. At my waking I found the houses covered with snow, a rare sight, not seen for three years.

1667.—27th. It now being fine, people are again walking about the streets.

1668.—6th. To the play; the King was there; I into the pit, it being dark and raining hard—at last I found my wife.

——.—23rd. To Mile End, to get a little air, but the way was mighty dirty from the late rains.

March.

1660.—21st. The wind to-day was mighty strong.

1667.—16th. The weather has now grown warm again after much cold.

April.

1661.—21st. This day the greatest shower of rain fell that ever I have seen.

1667.—27th. I down to walk in the gardens at Whitehall, it being a mighty hot and pleasant day.

May.

1660.—21st. The weather foul all this day.

1668.—22nd. It rained very hard all this day; the King gone to Newmarket to see the horses race, all in the same wet.

June.

1664.—1st. To the play; before it was done there fell such a storm of hayle that we in the pitt were fain to rise, and all the house was in confusion.

1664.—11th. With my wife to take the air at Bowe, it being very warm and pleasant.

July.

1662.—19th. In the afternoon I went on the river, where it rained so hard I came ashore, whilst the King came by in his barge; it lessened my esteem for a king that he was not able to command the weather.

August.

1663.—28th. Cold all last night, and a very great frost they say abroad, which is much, we having had no summer at all almost.

1664.—16th. Wakened about two o'clock this morning with the noise of thunder, and which lasted for an hour, with continued lightning, not flashes, but flames, and for a great while not a moment space between the flashes, such as I had never seen, or believe to have been seen, and accompanied with such a downpour of rain I expected my house to have been overflowed therewith.

1667.—11th. To the wells at Barnet, but the morning was very cold; we were all very cold on the coach.

———.—27th. It was raining all this day, to our great joy, it not having rained before this month. The ground was everywhere burnt, and dry as could be, and no travelling in the streets of London for the dust.

September.

1661.—30th. Up at five o'clock this morning, the moon shining brightly.

1663.—19th. Waked this morning with a very high wind, and said to my wife, "I pray we hear not of the death of some great person, this wind being so high."

1665.—20th. The great plague increased this week by 600 deaths more than last week, which is quite contrary to our hopes from the coldness of the season.

1667.—5th. I laid down in my office, being mighty weary, and about two o'clock in the morning called up, telling me the great fire has come to Barking Church. What a dreadful sight it was, to see by moonlight the city all on fire!

———.—7th. Up by five o'clock, and by water to St. Paul's warfe. A miserable sight to see St. Paul's Church with all the roof fallen in.

———.—9th. To my office, though it was raining hard, which it had not done for a long while before.

———.—27th. A very furious wind blowing all last night, my mind mightily perplexed with dreams and fire.

November.

1662.—29th. A very hard frost, which is news, after having none for three years.

1665.—27th. I back to London, it being unsafe to go by water in this dark, cold, frosty weather.

December.

1662.—15th. The Duke to-day went sliding on the ice in the Park; he slides very well.

1663.—7th. Last night was the greatest tide ever known in the Thames; all Whitehall was drowned.

RECENT PUBLICATIONS.

Abhandlungen des Königlich Preussischen Meteorologischen Instituts. **Band 2.** No. 3. *Ueber die Kälterückfälle im Juni.* Von W. MARTEN. 20 pp. and 3 pl. Berlin, 1902. No. 4. *Katalog bemerkenswerter Witterungsereignisse von den ältesten Zeiten bis zum Jahre* 1800. Von Dr. R. HENNIG. 93 pp. Berlin, 1904 4to.

The first of these papers deals with the question of cold days in June, based on observations extending from 1881 to 1899. The latter paper gives an interesting chronological list of meteorological events, extending from 1754 B.C. to 1799 A.D. The earlier entries give such events as storms, overflowings of the Nile, etc.

Anales del Instituto y Observatorio de Marina de San Fernando. **Sección 2ª.** *Observaciones meteorologicas, magneticas y sísmicas Ano.* 1902. San Fernando, 1903. 4to. 160 pp. and 2 pl.

This volume contains the hourly meteorological observations made in 1902, also the magnetical and seismological observations.

Annales du Bureau Central Météorologique de France. Publiées par E. MASCART, Directeur. Année 1900, 3 vols. Année 1901, 3 vols. 4to. Paris, 1902-3.

Part I., Memoires, contains the following papers:—"Report on the Work of the Bureau Central Météorologique de France," by M. Bouquet de la Grye, President of the Council; "Thunderstorms in France, and the State of the Atmosphere in 1900 and 1901," by M. Fron; "Magnetic Observations made at Parc St. Maur," by M. Th. Moureaux; "Magnetic Observations made at the Perpignan Observatory," by M. P. Coeurdevache; "Studies on the Climate of France," by A. Angot; "Study of the Diurnal Variation of Atmospheric Electricity," by A. B. Chauveau; "Magnetic Observations made at the Observatory of Val.-Joyeux, 1901," by M. Th. Moureaux; "The Climate of Camp Jacob (Guadeloupe)," by A. Angot; "Magnetic Survey of France, January 1, 1896," by M. Th. Moureaux.

Part II. contains the observations made during the years 1900 and 1901.

Part III. contains the daily observations of rainfall.

Aus dem Archiv der Deutschen Seewarte. **26.** 1903. Hamburg, 1903. 172 pp. and 5 pl.

This volume contains the following papers:—"Ueber die Berechnung von Mond-Distanzen mit Hülfe der Mercator schen Funktionen": von Prof. Dr. C. Börgen (12 pp.).—"Bestimmung der Polhöke der Sternwarte zu Heidelberg und ihrer Variation": von Dr. A. Caspar (71 pp.).—"Die tägliche Variation der magnetischen Deklination": von Dr. A. Nippoldt, Jr. (28 pp. and 4 pl.).—"Die Drehung der Winde an der deutschen Küste im täglichen und jahrlichen Gang": von Dr. L. Grossman (22 pp. and pl.).—"Ueber die Gänge der Normal-

Uhren der Deutschen Seewarte": von K. Heuer (6 pp.), and "Definitive Bahnbestimmung des Kometen 1887 II. (Brooks)": von Prof. Dr. C. Stechert (31 pp.).

Bulletin Mensuel de l'Observatoire Météorologique de l'Université d'Upsal. Vol. **35.** 1903. 74 pp. Upsal, 1903-4. 4to.

This volume contains the hourly and daily observations made at the Meteorological Observatory at Upsala during 1903.

Observations Météorologiques Suédoises. Publiées par l'Académie Royale des Sciences de Suéde, exécutees et rédigées sous la direction de l'Institut Central de Météorologie. Vol. **43.** 1901. 10 + 155 pp. 4to. Stockholm, 1903.

This volume contains the results of meteorological observations made in Sweden during the year 1901.

Climatology of California. Prepared under the direction of Willis L. Moore, Chief U.S. Weather Bureau, by ALEXANDER G. M'ADIE, Professor of Meteorology U.S. Department of Agriculture. Weather Bureau. Bulletin L. 4to. 270 pp. and 19 plates. Washington, 1903.

This is an interesting and elaborate monograph. The author points out that the general climatic conditions of the Pacific coast, and particularly the climate of California, are controlled by the following four great factors, viz.: (1) The movements of the great continental and oceanic areas—the so-called permanent "highs" and "lows." Under this head he includes also the most active factor in climatic development, namely, the movements of individual pressure areas, since there is good ground for believing that the paths of these individual disturbances—large-sized whirls and counter-whirls—are largely determined by the general relations of the permanent pressure areas; (2) The prevailing drift of the atmosphere in temperate latitudes from west to east; (3) The proximity of the Pacific Ocean with a mean annual temperature near the coast-line of about 55°, a great natural conservator of heat, and to which is chiefly due the moderate range of temperature along the coast of San Diego even to Tatoosh Island; and (4) The exceedingly diversified topography of the country for a distance of 200 miles from the coast inland.

Accounts are given of the climates of the north and central coast, the southern coast, the Great Valley, and Santa Clara Valley. These are followed by precipitation tables, and articles on frost, fog, thunderstorms, and earthquakes. Some very interesting photographs of fog billows often seen in the neighbourhood of San Francisco are included in the volume.

Observatoire Royal de Belgique. Annuaire Météorologique pour 1904. Publié par les soins de A. LANCASTER. Bruxelles. 1904. 7 + 664 pp.

In addition to the usual information, this volume contains the following articles:—"Comparaison entre les Observations Météorologiques faites simultanément a Bruxelles et a Uccle de 1886 à 1900," par A. Lancaster (20 pp.).—"Note sur la nébulosité a Bruxelles," par A. Bracke (11 pp.).—Étude complémentaire sur la marche des cirrus dans les zones de haute pression," par E. Vanderlinden (25 pp.).—"Aperçu des résultats météorologiques de l'hivernage antarctique de la *Belgica*," par H. Arctowski (39 pp.).—"Le tir contre la grêle," par E. Vanderlinden (41 pp.). A very complete list of the published papers on "Hail Shooting" is given as an Appendix to this article.

Regenwaarnemingen in Nederlandsch-Indië, 1902. 10 + 510 pp. **Batavia**, 1903. 4to.

This volume contains the rainfall records at 226 stations in the **East** Indian Archipelago.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

[**Abbe, C.**]—Desirability of Complete Rainfall Records. *Monthly Weather Review, Washington*, **32**, 1904 (79-80).

Abbot, G. C.—Recent Studies on the Solar Constant of Radiation. *Monthly Weather Review, Washington*, **31**, 1903 (587-592). Reprinted from *Smithsonian Miscellaneous Collections (Quarterly Issue)*, **45**, 1903.

Abbot, H. L.—Disposition of Rainfall in the Basin of the Chagres. *Monthly Weather Review, Washington*, **32**, 1904 (57-65).

Angot, A.—Les observations météorologiques de la Mission Saharienne Foureau-Lamy. *Ann. Soc. Mét. France, Paris*, **54**, 1904 (48-51).

Augustin, F.—Der tägliche Gang der meteorologischen Elemente auf der Petřínwarte in Prag. *Meteorologische Zeitschrift, Vienna*, **21**, 1904 (113-129).

Becke, v. d.—Das Sturmwarnungswesen europäischer Staaten. *Ann. d. Hydrog. u. Marit. Met. Berlin*, **1904** (147-158).

Bergholz.—Regenfall auf Ceylon. *Meteorologische Zeitschrift, Vienna*, **21**, 1904 (187-188).

Besson, L.—Essai de prévision méthodique du temps. *Ann. Soc. Mét. de France, Paris*, **52**, 1904 (92-97).

Besson, L.—A new Nephoscope. *Monthly Weather Review, Washington*, **32**, 1904 (13-14).

Bigelow, F. H.—Studies on the Circulation of the Atmospheres of the Sun and of the Earth. III. The Problem of the General Circulation of the Atmosphere of the Earth. *Monthly Weather Review, Washington*, **32**, 1904 (15-20). IV. Values of Certain Meteorological Quantities for the Sun. *Monthly Weather Review, Washington*, **32**, 1904 (71-78).

Börgen, C.—Gewitter-Fernregistrierung. *Meteorologische Zeitschrift, Vienna*, **21**, 1904 (138-139).

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THE VARIATION OF THE POPULATION OF INDIA COMPARED WITH THE VARIATION OF RAINFALL IN THE DECENNIUM 1891-1901.

BY W. L. DALLAS.

[Read April 20, 1904.]

IN the following pages are given (1) a brief account of the annual and total variations of the rainfall over India during the decade 1891 and 1901; and (2) a statement of the variations of the population of India according to the census of 1901, as compared with the census of 1891.

The annual rainfall returns and variations employed for the investigation are those from April 1 to March 31 for each year, so that the total rainfall refers to the total fall which occurred during the 10 years preceding March 31, 1901. The actual dates of the two censuses were February 26, 1891, and March 1, 1901, so that the two periods, one of rainfall statistics and the other of population statistics, are close enough for all practical purposes.

Taking the 10 twelve-monthly periods (April 1 to March 31) separately, the following variations of rainfall were determined for the whole Indian area:—

1891-2.	1892-3.	1893-4.	1894-5.	1895-6.	1896-7.	1897-8.	1898-9.	1899-1900.	1900-1.
ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
−5·64	+5·56	+5·50	+7·81	−6·25	−3·57	+0·45	+0·17	−6·69	−0·09

The preceding figures show how very large were the vicissitudes of climate over India during the decade under review. The mean average rainfall of the Indian Continent for a year has been calculated to be 41·09 ins., so that in the year 1894-5 the total rainfall was 19 per cent in excess of the normal, while in the year 1899-1900 it was 17 per cent in defect, giving a total variability of rainfall during these 10 years of 36 per cent. The table likewise shows that during the decade there were

TABLE I.—Rainfall Variations and Percentages for the 4 Years' Period April 1891 to March 1895.

Province and Division.	1891-2.	1892-3.	1893-4.	1894-5.	Total Variation.	Normal Rainfall for 4 Years' Period.	Percentage of Rainfall for the Period.
Burma.	ins.	ins.	ins.	ins.	ins.	ins.	%
Tenasserim	+34·27	+17·57	+22·21	+85·97	+160·02	740·08	122
Lower Burma Deltaic	+17·31	− 6·59	− 3·09	+ 7·99	+ 15·62	409·40	104
Central Burma	− 2·84	− 2·73	− 4·56	+ 0·01	− 10·12	256·12	96
Upper Burma	−24·59	−14·91	−10·60	− 9·88	− 59·98	221·92	73
Arakan	− 1·09	−10·92	− 0·02	−14·66	− 26·69	760·36	96
Bengal and Assam.							
Eastern Bengal	−25·43	− 3·81	+18·23	+ 1·06	− 9·95	354·40	97
Assam, Surma	−20·04	+39·48	+11·09	+ 2·56	+ 33·09	566·76	106
,, Brahmaputra	−16·26	+10·82	− 6·78	+ 8·17	− 4·05	339·32	99
Deltaic Bengal	−15·13	− 3·74	+11·55	− 1·55	− 8·87	242·28	96
Central Bengal	−12·31	− 5·33	+10·95	+ 2·34	− 4·35	225·00	98
North Bengal	−36·45	+27·01	+12·54	+ 4·00	+ 7·10	380·12	102
Orissa	− 1·83	− 2·17	+15·71	+ 0·87	+ 12·58	238·96	105
Chota Nagpur	− 7·83	− 2·28	+10·22	+10·82	+ 10·93	215·84	105
South Bihar	−10·38	− 4·72	+ 6·36	+13·31	+ 4·57	175·48	103
North Bihar	−13·65	+ 3·49	+10·34	+ 5·61	+ 5·79	214·72	103
United Provinces of Agra and Oudh.							
United Provinces, East	− 5·86	+ 1·35	+14·28	+25·35	+ 35·12	153·00	123
South Oudh	+ 0·23	+ 4·73	+13·75	+29·78	+ 48·49	144·40	134
North Oudh	+ 1·82	+ 3·84	+11·24	+28·81	+ 45·71	155·80	129
United Provinces, Central	+ 3·43	+ 2·23	+ 6·90	+27·15	+ 39·71	137·24	129
,, West	+ 5·50	+ 5·13	− 0·04	+ 9·04	+ 19·63	105·32	119
,, Submontane	+ 0·21	+ 3·01	+13·36	+19·40	+ 35·98	177·80	120
Punjab & North-West Frontier Province.							
South Punjab	− 4·56	+ 9·36	+ 7·48	+ 7·51	+ 19·79	64·00	131
Central Punjab	+ 1·63	+ 7·80	+ 6·37	+ 8·60	+ 24·40	75·48	132
Punjab, Submontane	−10·24	+13·57	+12·06	+15·50	+ 30·89	123·44	125
,, Hills	−10·46	+10·39	+ 8·78	+31·21	+ 39·92	247·88	116
North Punjab	− 9·02	+ 8·48	+11·70	+ 6·58	+ 17·74	84·92	121
West Punjab	− 3·59	+ 8·74	+ 4·35	+ 2·79	+ 12·29	35·60	135
Bombay and Malabar Coast Districts (Madras).							
Malabar	− 7·16	+19·18	− 7·87	−10·08	− 5·93	500·32	99
Madras, South Central	+ 7·16	− 2·20	+ 5·08	− 2·45	+ 7·59	117·44	106
Mysore	− 7·16	− 1·29	− 1·49	− 8·78	− 18·72	142·44	87
Konkan	−26·68	+16·50	− 3·52	− 1·37	− 15·07	460·76	97
Bombay Deccan	− 3·06	+14·02	+ 2·88	− 0·80	+ 13·04	143·92	109
Khandesh	− 6·45	+ 7·05	+ 3·47	+ 1·77	+ 5·84	131·08	104
Central Provinces and Berar.							
Berar	+ 1·83	+20·63	− 2·29	+ 3·26	+ 23·43	158·72	115
Central Provinces, West	+ 5·00	+17·61	− 2·05	+ 8·84	+ 29·40	178·68	116
,, Central	+11·57	+ 1·08	+ 5·78	+ 8·52	+ 26·95	206·12	113
,, East	+ 5·78	+10·42	+ 9·68	+13·13	+ 39·01	200·32	119

TABLE I.—Rainfall Variations and Percentages for the 4 Years' Period, April 1891 to March 1895—*continued.*

Province and Division.	1891-2.	1892-3.	1893-4.	1894-5.	Total Variation.	Normal Rainfall for 4 Years' Period.	Percentage of Rainfall for the Period.
Bombay (North).	ins.	ins.	ins.	ins.	ins.	ins.	%
Gujarat	− 5·94	+ 6·90	+ 5·15	+14·47	+20·58	176·60	112
Kathiawar and Cutch .	− 4·58	+ 5·67	+ 2·11	+19·82	+23·02	112·56	120
Sind	− 4·16	+ 6·37	− 1·49	+ 2·49	+ 3·21	22·40	114
Rajputana & Central India.							
Central India, East .	− 2·48	+ 2·11	+ 0·81	+ 4·90	+ 5·34	171·72	103
Rajputana, East; Central India, West	− 7·38	+ 7·64	+ 1·19	+ 4·02	+ 5·47	112·76	105
West Rajputana . .	− 5·73	+11·06	+12·65	+ 3·32	+21·30	50·12	142
Madras.							
East Coast, North . .	−15·25	+13·05	+ 8·96	+ 2·55	+ 9·31	164·68	106
Madras, Central . .	−15·77	+ 6·70	+ 2·08	− 0·92	− 7·91	99·40	92
East Coast, Central .	−19·11	+ 1·30	+ 5·96	− 4·08	−15·93	132·64	88
East Coast, South . .	− 4·87	−10·13	+ 2·91	− 6·34	−18·43	166·24	89
Madras, South . .	+ 1.05	− 6·55	− 0·55	− 5·66	−11·71	114·12	90
Means	− 5·64	+ 5·56	+ 5·50	+ 7·81	+13·23	216·85	106

three years (from 1892 to 1895) of excessive rain; three years (1897, 1898, and 1900) of normal rain; and four years (1891, 1895, 1896, and 1899) of deficient rain; so that the deficient years as compared with normal and excessive years were in the proportion of 2 to 3.

The first year of the series was one of deficient rainfall, the total deficiency for the whole country averaging − 5·64 ins. Referring to Table I., which gives the distribution of the annual rainfall according to divisions, it will be seen that the deficiency extended over by far the larger part of the country, the rainfall having been excessive only over three relatively small areas; the first includes the Central Provinces and the adjoining parts of the United Provinces and of the Central Punjab; the second includes Tenasserim and Lower Burma; and the third includes South Madras. The succeeding three years were years of plentiful rain, the mean excess having been 5·56 ins. in 1892-3, 5·50 ins. in 1893-4, and as much as 7·81 ins. in 1894-5. Both the amount of the rainfall and the extent of the area of excess increased during these three years, the number of divisions reporting excessive rain having been 34 in 1892, 35 in 1893, and 36 in 1894. In addition to this increase in the amount and extent of the rainfall, it would appear that the area of greatest excess was propagated northward during these three years. The rainfall variations of the year 1892 show that the excess in that year was greatest over Malabar, the Konkan, the Bombay Deccan, Berar, and the west of the Central Provinces; those of 1893 show that the greatest excess lay over an area running from Orissa through the Central and United Provinces to West Rajputana; while those of 1894 show

that the excess in that year was greatest over the Punjab hills and Oudh. There was thus some evidence pointing to the progress northward of a zone of excessive rain during these three years. This advance was followed by the appearance of a zone of deficient rain in the south. Thus in Malabar, the Konkan, etc., deficient rainfall had already commenced to appear in 1893, and the deficiency in these areas became very pronounced in 1894.

In this connection it is interesting to note that it would appear, from the list of droughts given in the *Report of the Indian Famine Commission*, that on no less than five occasions during the last century a serious failure of the rainfall over the Peninsula has been followed by a similar failure in Northern India in the next year. These instances are as follows :—

1782 Drought in Bombay and Madras.
1783 Drought in Upper India.

1802 Drought in South Hyderabad and Deccan.
1803 Drought in United Provinces and Central India.

1823 Drought in Madras.
1824 Drought in Bombay, Gujarat, and North Deccan.

1832 Drought in North Madras.
1833 Drought in North Bombay, Rajputana, Punjab, and United Provinces.

1876 Drought in Madras, Deccan, etc.
1877 Drought in United Provinces, Central Provinces, and Punjab.

This establishes a *prima facie* case in favour of the northward progression over India of zones of deficient rainfall ; and the evidence of the variations of rainfall during the 10 years under review appears to point to a similar progression of the zones of excessive rain.

With the close of 1894 the years of plentiful rainfall ceased, and a series of "lean" years commenced. The rainy seasons of the years 1895 and 1896 had very short rainfall. In 1895 drought extended to practically all parts of the country except portions of Madras, the whole number of divisions affected by deficient rain having been 41. In the following year, 1896, the total number of divisions affected was only 32, so that the area of drought had contracted, though over Assam, Bengal, Bihar, the United Provinces, the Punjab, Central India, Rajputana, and Berar the failure of the rains was as pronounced as in 1895, and in some divisions the deficiency had actually intensified. In 1897 the mean actual rainfall of the whole country just exceeded the normal, but there were certain areas, *e.g.* parts of Bengal, of the South and Central Punjab, of Central India, of Rajputana, and of North Bombay, where there had been no change in the rainfall conditions, and where the deficiency, which had commenced in 1895, was maintained throughout the whole three years. In 1898 the rainfall conditions exhibited but little change as compared with those of 1897. The total average actual rainfall of the whole country, as in the preceding year, just exceeded the normal, a result due to good rains over Bengal, the United Provinces, and the Peninsula. Elsewhere there had been no improvement. In the Punjab general deficiency was reported, a condition which extended southward over Rajputana to Gujarat, Kathiawar, and Sind ; and south-eastward over Central India, to Berar and the Central

Provinces. In Upper Burma and South Assam the year's rainfall was also largely deficient.

The preceding summary has shown that 1895 and 1896 were years of decided and widespread drought, and that they were followed by two years during which the rainfall of the whole country was just normal. This increase in the rainfall was not, however, common to the whole continent. Those areas which were most affected by the drought of 1895-6 continued to report deficient rainfall. Looking along the line of figures in Table II., it will be seen that the rainfall was more or less continuously deficient over the greater part of the Punjab, Rajputana, Central India, Gujarat, Berar, and a large part of the Central Provinces from 1895 to 1898. The whole of this large area was consequently ill-prepared to resist the acute drought which followed in 1899. In the latter year the rainfall of the whole country was in larger defect than in any other year of the series under discussion. The region affected by drought contained, however, only 34 divisions, so that the drought area was less in extent than in 1895. On the other hand the failure of the rainfall was more complete and intense than in any other season. Thus along the Bombay coast the year's rainfall was only 50 per cent of the normal; in Gujarat only 28 per cent, and in other provinces of Central and Western India the deficiency was equally great. This drought, acute enough in itself, came, as has been shown above, at the close of four years of more or less deficient rainfall. The following year, 1900, was one of normal rainfall. The divisional variations during this year show that the rainfall was irregularly distributed, but fortunately included an excess over the Punjab, parts of Rajputana, Central India, the Central Provinces, and Kathiawar, where the drought of the preceding years had been most intense.

The above data show that the decade in the matter of rainfall variation may be conveniently separated into two divisions, viz. (1) April 1, 1891, to March 31, 1894, during which, with the exception of 1891, the rainfall was normal or heavy over nearly the whole country; and (2) April 1, 1895, to March 31, 1901, during which, at its best, the rainfall was barely normal, and at its worst was phenomenally deficient. The two charts, Figs. 1 and 2, exhibit the total variations of rainfall for the two periods of excess and defect.

These charts show that during the wet period the rainfall was deficient over Upper Burma and Madras, was normal over the remainder of Burma, Assam, Bengal, and the West Coast of the Peninsula, and was excessive elsewhere; while during the dry period the rainfall was again deficient over Upper Burma, normal or excessive over the remainder of Burma, Assam, Bengal, the United Provinces (north of the Ganges), the North-West Frontier Province, and the south of Madras, and was deficient elsewhere—most so over Rajputana and neighbouring areas.

The third general census of India was recorded on the night of March 1, 1901. The total population enumerated was 293,475,477, an increase compared with the numbers recorded in 1891 of 6,079,483, or 2·1 per cent. But 2,293,629 of this increase was due to the inclusion of territories not included in the 1891 census, so that excluding these territories the total increase was only 3,785,854, or only 1·3 per cent.

The population had thus failed to increase according to the normal

TABLE II.—Rainfall Variations and Percentages for the 6 Years' Period, April 1895 to March 1901.

Province and Division.	1895-6.	1896-7.	1897-8.	1898-9.	1899-1900.	1900-1.	Total Variation.	Normal Rainfall for 6 Years' Period.	Percentage of Rainfall for the Period.
Burma.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	%
Tenasserim	− 2·50	+33·47	− 5·56	+14·86	− 14·69	− 0·24	+25·34	111·12	102
Lower Burma Deltaic	− 8·67	+17·53	+ 0·48	+ 3·70	− 2·76	+ 5·81	+16·09	614·10	103
Central Burma	− 10·99	− 7·11	+ 1·85	− 6·60	− 2·39	+ 5·39	− 19·85	384·18	95
Upper Burma	− 14·77	− 20·99	− 11·09	− 15·36	− 5·04	− 12·06	− 79·31	332·88	76
Arakan	− 48·42	+ 2·15	+ 6·66	− 1·64	+10·18	− 37·39	− 68·46	1140·54	94
Bengal and Assam.									
Eastern Bengal	− 11·70	− 17·88	− 2·32	+ 7·42	+21·77	− 10·19	− 12·90	531·60	98
Assam, Surma	− 7·91	− 20·78	+ 0·21	− 26·91	+16·42	− 38·89	− 77·86	850·14	91
,, Brahmaputra	− 6·12	− 11·71	+ 0·64	+ 2·91	+14·14	− 15·95	− 16·09	508·98	97
Deltaic Bengal	− 17·80	− 8·20	− 0·81	+ 2·78	+13·11	+17·04	+ 6·12	363·42	102
Central Bengal	− 16·73	− 11·13	− 4·14	+ 8·37	+ 5·94	+ 0·12	− 17·57	337·50	95
North Bengal	− 5·34	− 19·77	− 2·21	+ 0·54	+ 6·23	− 18·80	− 39·35	570·18	93
Orissa	+ 5·06	+ 4·90	− 3·58	− 2·94	− 5·92	+14·38	+11·90	358·44	103
Chota Nagpur	− 6·84	− 0·49	− 1·48	+ 2·30	− 6·63	+ 9·30	− 3·84	323·76	99
South Bihar	− 5·97	− 8·13	+ 8·52	+10·35	+13·56	− 1·67	+16·66	263·22	106
North Bihar	− 1·80	− 16·44	− 0·17	+ 7·26	+19·71	− 0·93	+ 7·63	322·08	102
United Provinces of Agra and Oudh.									
United Provinces, East	− 4·63	− 12·89	+10·34	+11·20	+10·16	− 0·16	+14·02	229·50	106
South Oudh	− 2·75	− 16·36	+ 3·52	+ 7·15	+ 5·17	+ 0·88	− 2·39	216·60	99
North Oudh	+ 4·70	− 6·73	+ 3·74	+11·35	+ 5·45	+ 1·14	+19·65	233·70	108
United Provinces, Central	− 4·75	− 13·09	− 0·59	+ 6·30	+ 0·21	− 1·46	− 13·38	205·86	94
,, West	− 3·67	− 7·67	+ 7·60	− 4·68	− 6·99	+ 2·40	− 13·01	157·98	92
,, Submontane	− 0·37	− 12·90	+ 5·50	+ 6·11	+ 4·19	+ 1·50	+ 4·03	266·70	102
Punjab & North-West Frontier Province.									
South Punjab	− 3·03	− 5·94	− 0·59	− 4·81	− 9·76	+ 8·22	− 15·91	96·00	83
Central Punjab	− 6·77	− 6·29	− 1·48	− 4·86	− 10·59	+ 1·97	− 28·02	113·22	75
Punjab, Submontane	− 9·25	− 7·58	− 3·86	− 4·94	− 14·03	+16·37	− 23·29	185·16	87
,, Hills	− 5·26	− 6·24	− 8·39	− 9·52	− 18·80	+17·82	− 30·39	371·82	92
North Punjab	− 3·81	− 1·61	+ 3·90	− 0·19	− 4·44	+ 7·66	+ 1·51	127·38	101
West Punjab	+ 0·60	− 2·46	+ 4·21	− 2·10	− 5·03	− 0·37	− 5·15	53·40	90
Bombay and Malabar Coast Districts (Madras).									
Malabar	− 3·02	+18·04	+33·40	− 1·29	− 27·63	+12·89	+32·39	750·48	104
Madras, South Central	+ 5·38	+ 2·27	+ 2·99	+ 7·42	− 5·33	− 0·43	+12·30	176·16	107
Mysore	− 2·81	− 1·10	+ 0·79	+ 3·22	− 10·25	− 2·46	− 12·61	213·66	94
Konkan	− 11·66	+ 4·36	+12·23	+ 7·42	− 57·04	− 0·69	− 45·38	691·14	93
Bombay Deccan	− 1·07	+ 2·86	+ 0·86	+ 1·67	− 15·57	− 1·94	− 13·19	215·88	94
Khandesh	− 2·96	− 1·29	− 1·13	− 4·04	− 19·33	− 3·29	− 32·04	196·62	84
Central Provinces and Berar.									
Berar	− 12·03	− 11·63	− 7·59	− 12·98	− 26·29	− 3·89	− 74·41	238·08	69
Central Provinces, West	− 5·31	− 2·19	− 0·97	− 3·75	− 25·84	+ 4·76	− 33·30	268·02	88
,, Central	− 9·24	+ 1·58	− 3·98	+ 1·50	− 26·45	+ 5·85	− 30·74	309·18	90
,, East	− 5·05	+20·55	+ 3·02	− 4·38	− 13·23	+21·15	+22·06	300·48	107

TABLE II.—Rainfall Variations and Percentages for the 6 Years' Period, April 1895 to March 1901—*continued.*

Province and Division	1895-6	1896-7.	1897-8.	1898-9.	1899-1900.	1900-1.	Total Variation.	Normal Rainfall for 6 Years' Period.	Percentage of Rainfall for the Period.
Bombay (North).	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	%
Gujarat	- 11·60	+ 1·68	- 8·07	- 1·10	- 31·89	- 9·21	- 60·19	264·90	77
Kathiawar and Cutch	- 6·61	+ 0·55	+ 2·45	- 4·26	- 21·27	+ 1·26	- 27·88	168·84	83
Sind	- 0·76	- 0·29	+ 2·86	- 0·58	- 5·57	- 1·19	- 5·53	33·60	84
Rajputana & Central India.									
Central India, East	- 13·88	- 12·68	- 6·60	- 5·41	- 15·87	- 2·91	- 57·35	257·58	78
Rajputana, East; Central India, West	- 9·46	- 8·74	- 4·36	- 9·69	- 13·39	+ 4·44	- 41·20	169·14	76
West Rajputana	- 3·86	- 1·23	+ 2·03	- 4·88	- 10·05	+ 1·57	- 16·42	75·18	78
Madras.									
East Coast, North	- 14·58	- 8·30	+ 6·73	+ 0·46	- 8·93	- 1·68	- 26·30	247·02	89
Madras, Central	+ 1·31	- 10·05	- 1·27	- 2·97	- 8·81	- 1·33	- 23·12	149·10	84
East Coast, Central	- 4·25	+ 2·53	- 10·69	+ 2·77	- 9·41	- 4·93	- 23·98	198·96	88
East Coast, South	+ 5·46	+ 3·54	- 9·76	+ 15·05	- 5·16	- 2·04	+ 7·09	249·36	103
Madras, South	+ 5·42	+ 12·76	- 2·23	+ 5·83	- 2·98	+ 7·92	+ 26·72	171·18	116
Means	- 6·25	- 3·57	+ 0·45	+ 0·17	- 6·69	- 0·09	- 15·98	325·27	95

rate during the decade. Part of this failure was no doubt due to epidemics. Deaths from cholera amounted to 4,505,019; plague had commenced its ravages, and about 321,000 deaths were attributable to this disease during the decennium; while acute outbreaks of malarial fever, following the heavy autumn rainfall of 1893 and 1894, accounted for hundreds of thousands of deaths; yet the principal cause of the failure to increase at the normal rate was undoubtedly due to the variations of rainfall.

The census of March 1, 1901, was recorded at the close of a period of six years, during which the rainfall was practically continuously deficient over a large part of the country, and the chart, Fig. 3, which is taken from the *Annual Report of the Sanitary Commissioner with the Government of India for* 1901, exhibits an unmistakable relationship between the variations of the population and the variations of rainfall during these six dry years. If this map be carefully compared with the rainfall variation map of the dry period (Fig. 1), it will be seen that the area within which the most serious decrease of population occurred coincides almost exactly with the area of greatest deficiency of rainfall. In Berar the variation of the rainfall of the dry period was – 31 per cent, while the population decreased 4·9 per cent. In East Rajputana the rainfall variation was – 24 per cent, and the population decreased 12·0 per cent; in West Rajputana the variation of rainfall was – 22 per cent, and the population decreased 18·9 per cent; in Gujarat the variation of rainfall was – 20 per cent, and the population decreased 19·1 per cent; in Central India the variation of rainfall was – 22 per cent, and the population

decreased 14·8 per cent; and in the Central Provinces the variation of rainfall was – 5 per cent, and the decrease of the population was 8·0 per cent. In this region most districts suffered severely from famine and its effects, and the population was further diminished by emigration to Assam and Bihar. Sambalpur, in the east of the province, had an excess of rain during both periods, and suffered little from drought. In Bombay the variation of rainfall was – 11 per cent, and the decrease of the popula-

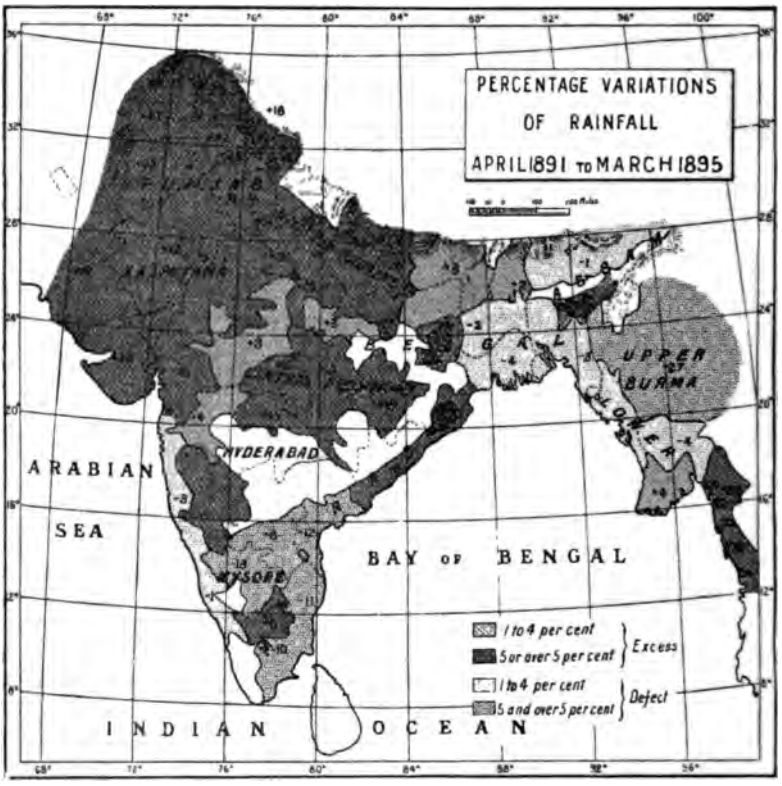


FIG. 1.—Wet Period.

tion 8·1 per cent. There was thus a close dependence of the condition of the Indian peoples on a sufficient and normally distributed rainfall. The principal departures from this agreement are—(1) the Indus Valley, where rainfall was in defect, but the population increased; (2) the South-east Punjab and neighbouring parts of the United Provinces, where a similar relation prevailed; (3) parts of Oudh and Bihar, where the rainfall was heavy but the population decreased; and (4) parts of the east coast and Central Madras, where the rainfall was deficient but the population increased. With regard to (1) and (2), irrigation probably accounts for the failure of the population to diminish under the influence of deficient rain; in (3) the decrease in the population appears to have been due to an excess of rain and the subsequent outbreak of malaria; while for (4) no explanation suggests itself, as this area experienced more

or less deficient rain throughout the whole decennium. In Burma, Bengal, Assam, Orissa, Chota Nagpur, Bihar, and up the trans-Gangetic portion of the Gangetic Plain as far as the borders of the Punjab, the rainfall was generally normal or heavier than usual during the decade, and over the whole of this area the population generally increased. There were, however, numerous exceptions which show that though the general population of the province had increased there were districts in

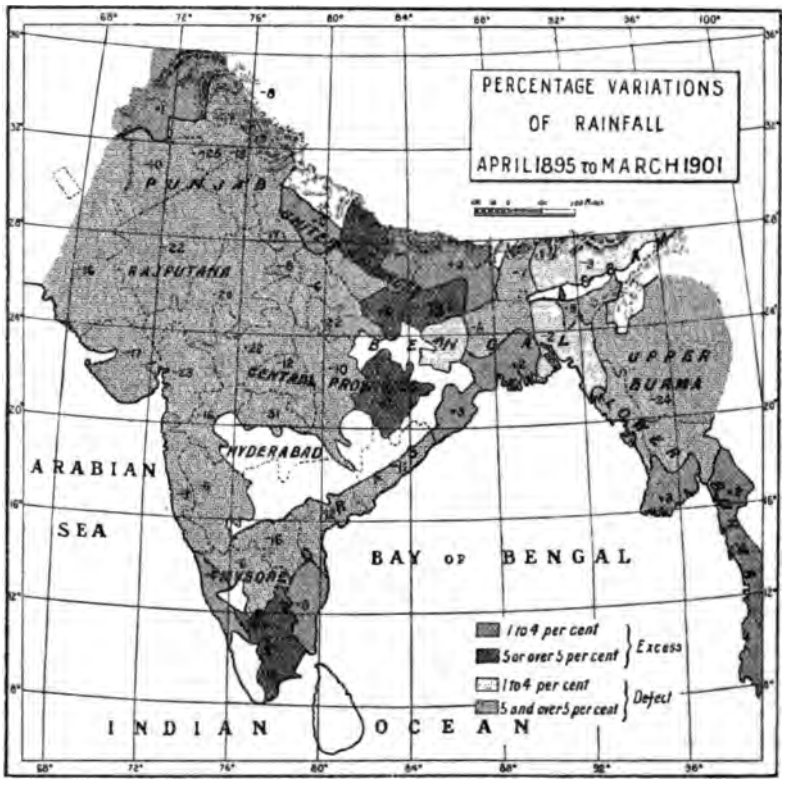


FIG. 2.—Dry Period.

which it had diminished. These failures to conform to the general relation appear to have been due, in many cases at least, to unhealthiness induced by an excess of rain rather than its deficiency.

Table III. shows approximately the percentage variations of the population and of the rainfall (1) in the wet period, (2) in the dry period, and (3) for the whole period for purposes of comparison.

Table III. and the charts of variation of rainfall and of population show that the decrease in the population was almost wholly due to the six "lean" years, 1895 to 1900. The heavy rainfall of the first four years of the decade was helpless to avert this calamity, as the surplusage of water had all disappeared before the "lean" years declared themselves. Yet if we consider the rainfall of the whole decade the actual deficiency of rain—notwithstanding that the period included a year of phenomenal

TABLE III.

Province or Division.	Increase or Decrease of Population.	Variation of Rainfall		
		In Wet Period.	In Dry Period.	In Decennium.
	%	%	%	%
Burma	+19·5	− 2	− 6	− 4
Bengal	+ 8·8	+ 1	0	0
Assam	+ 6·6	+ 3	− 6	− 2
United Provinces . . .	+ 1·4	+26	0	+11
Punjab and N. W. F. Province .	+ 5·7	+27	−12	+ 7
Central Provinces . . .	− 8·0	+16	− 5	+ 3
Berar	− 4·9	+15	−31	−13
East Rajputana . . .	−12·0	+ 5	−24	−13
West Rajputana . . .	−18·9	+42	−22	+ 4
Baroda (Gujarat) . . .	−19·1	+16	−20	− 5
Central India	−14·8	+ 3	−22	−12
Bombay	− 8·1	+ 6	−11	− 4
Mysore	+12·1	−13	− 6	− 9
Madras	+ 4·0	− 4	− 1	− 2

failure of the rains—was extraordinary small. This will be clear if the annual variations [1] be arranged under their plus and minus signs, thus :—

	ins.		ins.
1892-3	+ 5·56	1891-2	− 5·64
1893-4	+ 5·50	1895-6	− 6·25
1894-5	+ 7·81	1896-7	− 3·57
1897-8	+ 0·45	1899-1900	− 6·69
1898-9	+ 0·17	1900-1	− 0·09
	+19·49		−22·24
			+19·49
			− 2·75

The above shows that the total shortage of the rainfall was only about $\frac{3}{409}$ or $\frac{1}{136}$ of the total rainfall of the 10 years. The smallness of the total variation of rainfall compared with the very large annual variations was due to the compensatory character of the rainfall during the period under review. This compensatory character of the Indian rainfall, though interesting to the statistician, is of little material assist-

[1] The annual variations of the mean rainfall of India (excluding Burma), as given on page 675 of the *India Weather Review* for 1902, differ slightly from the above figures, as the year in the volume runs from January to December and the figures for Burma are omitted. The variations in the Annual Summary are as follows :—

	ins.		ins.
1892	+ 5·09	1891	− 3·54
1893	+ 9·07	1895	− 2·19
1894	+ 6·47	1896	− 4·83
1898	+ 0·43	1897	− 0·15
	+21·06	1899	−11·14
		1900	− 0·57
			−22·42
			+21·06
			− 1·36

According to these figures, while the annual variations were larger, the total variation for the decade was even smaller than that quoted above.

ance to the Indian peasant or cultivator. Three consecutive years of good rain, though they may ameliorate his condition, will not, as at present arranged, give him the power to face five years of drought, as is conclusively proved by the famine conditions, the deaths, and the emigration which took place over the central parts of India during the close of 1899 and the beginning of 1900. Whether this power can eventually be provided it is impossible at present to say, but it has at different times been asserted that by such precautions as the preservation of the surplusage of rainfall in good years, by means of a thorough

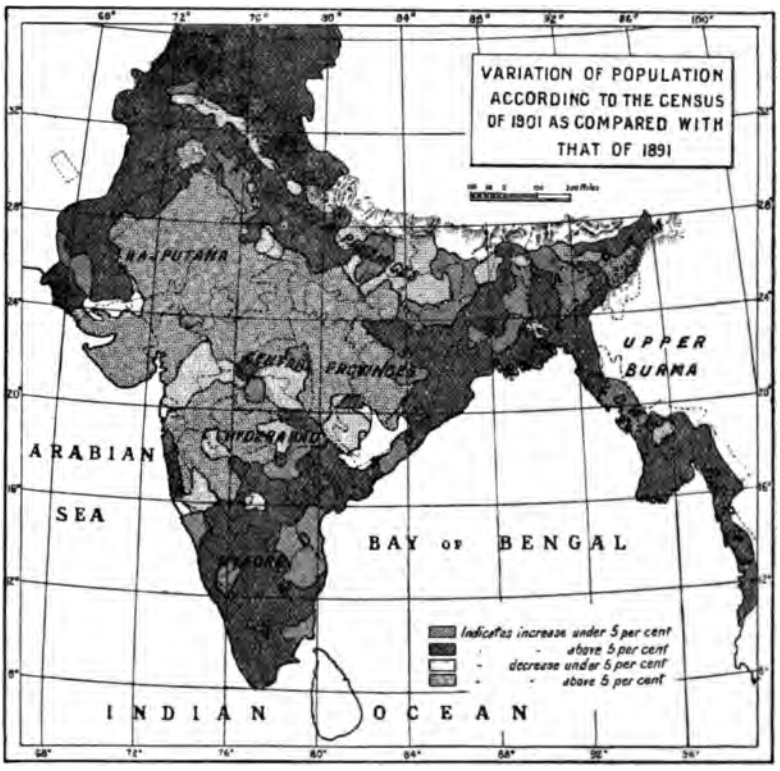


FIG. 3.

system of storage tanks or lakes, famine in India would practically cease. The evidence given by the present rainfall data bears out, so far as rainfall alone is concerned, this contention. Conditions in Egypt would appear to be to a certain extent parallel to those prevailing in India; periods of Nile flood corresponding with years of good rainfall, and periods of low Nile with years of deficient rainfall, and the system of basin irrigation of the ancient Egyptians, would appear to be particularly applicable to the river valleys of India. The ancient Egyptians led the flood, when it was dangerously high, by natural watercourses and artificial canals into neighbouring depressions, and provided for its return to the river when the inundation had subsided. It is not for the rainfall statistician to express any opinion as to the feasibility or otherwise of a

thorough system of storage lakes in India, or to say whether a Lake Moeris, to hold the surplus rainfall which now runs as a turbid flood to the sea, is possible or not on all the principal rivers of India. It is sufficient for him to indicate (1) the compensatory character of the Indian rainfall, and (2) to show that the variations in the Indian population during the decade under review were determined, not by the three years of heavy rainfall between 1892 and 1894, but by the famines and effects of famine resulting from the deficient rainfall between 1895 and 1900.

DISCUSSION.

Dr. A. Buchan remarked that there seemed to be no definite conclusions to be arrived at from the paper. He himself had looked into the question of the Bombay plague, and had collected four years' observations both of plague data and meteorological observations, and he had found that they did not correspond in any particular way. But on plotting the observations of the temperature of the soil 5 feet below the surface with the temperature above the ground, the curves ran exactly parallel in a remarkable manner. No doubt the warmer temperature of the subsoil caused exhalation to pass freely into the air above, and the people of the poorer classes, whose dwellings were mostly on the ground itself, speedily fell victims to the poisonous gases. Between the curves of mortality and the temperature of the subsoil and the temperature of the air above the ground a remarkable correspondence could be traced. In Edinburgh the doctors were very careful in watching the temperature of the soil 4 feet below the surface of the ground.

Mr. Baldwin Latham said that, judging from his own experience in India, and after the most careful investigation, he had come to the conclusion that the proper study of meteorological influences on health could best be carried out in such a country. The effect of a deficient rainfall caused a great increase in the death-rates both directly and indirectly, as influencing the food supply and inducing famine. As an example, in the year 1876 there was in Bombay a deficiency of rainfall, followed by a further deficiency in 1877, and the death-rate in 1877 rose to 52·0 per thousand against an average of 27·8 in the previous five years. The plague was influenced to a great extent by meteorological conditions, and as he had shown, exactly followed the tensional difference between the temperature of the ground at a depth of 5 feet and the tensional difference due to the temperature of the dew-point of the air, or that it arose from exhalations from a polluted and pest-sown soil.

Dr. H. R. Mill said that the paper had a special interest for him on account of the way in which it sought for a connection between varying meteorological conditions and vital statistics. The problem was one of great geographical interest, and he believed that the relations pointed out by the author were not likely to be set aside. He greatly regretted the absence of the author of the paper, because he felt that the subject would be elucidated if it had been possible to obtain further information on one or two points. The long experience of Mr. Dallas as a student of the Meteorology of India, and his familiarity with the methods of discussing meteorological data, made it easier to congratulate the author on the interesting results he had deduced from an important investigation than to criticise those results and the methods by which they had been arrived at. Still it might be permissible to put forward one consideration, not with the intention of controverting any part of Mr. Dallas's paper, but solely with the view of testing a particular method of

examination which the author had no doubt fully considered and deliberately adopted. He (Dr. Mill) felt that it should have been shown that the differences in the mean rainfall of India as a whole, from year to year, could be expressed by comparing the mean number of inches of rainfall in the constituent divisions of provinces—areas differing greatly in the amount of their precipitation. He would not himself care to adopt such a method in comparing the rainfall from year to year of so small and comparatively homogeneous a region as the British Isles. It seemed to him that the only possible way of comparing the fluctuations of rainfall in such a case was by reducing all the values to percentages and allowing for the area of the division, or by weighing the means in proportion to the areas to which they referred, so as to yield figures representative of the actual volume of precipitation. Thus, for instance, in Table I. it appeared that an excess of 160·02 ins. for four years in Tenasserim was equivalent to an excess of 22 per cent, while an excess of 21·30 ins. for the same period in West Rajputana corresponded to a percentage of 42, or nearly twice as great. It would consequently seem right, in considering the wetness or dryness of a period, to treat an excess of 1 in. in West Rajputana as equally significant with an excess of about 15 ins. in Tenasserim. Yet so far as can be seen, 1 inch in either place is treated as exactly equivalent. Without making any allowance for the areas of the various divisions, but merely averaging the percentage excesses instead of the inches of rainfall in excess, the percentage for the four years' period 1891-95 is found to be 109 instead of 106 as given in Table I., and similarly the percentage for the period 1895-1901 is found to be only 93 instead of 95; the contrast between the rainfall of India in the wet and dry portions of the decade being thus 16 per cent instead of 11 per cent. To obtain the real ratios, however—assuming the provincial means to be truly representative—the percentage for each division should be multiplied by the area, and the sum divided by the area of the whole of India, for which returns are given. He was of opinion that if this were done the case for a connection between the fluctuations of rainfall and the changes of population in India as a whole would probably be strengthened. It might be of course that the areas of the divisions of high and of low mean rainfall are so related as to make the arithmetical average of the percentages identical with the true average. Had Mr. Dallas been able to be present he could probably have settled the point at once.

The PRESIDENT (Capt. D. WILSON-BARKER) said that he thought that Mr. Dallas had clearly shown the interesting relation there was between the health of India and the meteorological conditions, and his paper was a valuable addition to the literature of the subject.

Dry Haze at Singapore.—There was a strange phenomenon here in 1902 which has not been explained. From September 20 to October 27 there was a persistent thick haze, so that for these thirty-eight days except once for two or three hours, we never saw sun or moon clearly. On some days for a couple of hours before sunset the sun appeared as a red ball casting no visible rays. The haze extended over the Peninsula and the Straits, and the surrounding seas as far as Java and Borneo, and was sometimes so dense as to detain a steamer. It was a dry haze, there being a noticeable absence, during its continuance, of the heavy dews so characteristic of this place. Moreover it was independent of changes of weather—whether there was cloud and rain or not made no difference. On the day that it ceased, a gentleman looking seaward, and seeing the air clear, said "Now we may expect normal weather"; but short rainfall continued as already stated. There were conjectures as to volcanic origin; but whence?

There was a rumour of some eruption in the southern part of Sumatra, and it was even said that Krakatoa was showing some signs of activity, but nothing definite came to our knowledge. If it was the result of more distant volcanic discharges it would surely have been observed elsewhere.—ARTHUR KNIGHT.

Ben Nevis Observatory.—It is announced that the high level observatory on Ben Nevis will be closed next month. The annual cost of the double observatory, high and low level, is close on £1000; of this sum about three-fourths is spent on the high level and about one-fourth on the low level station. The Treasury has offered to pay direct to the Scottish Meteorological Society on behalf of the Ben Nevis Observatory the £350 recommended by the Committee of Inquiry into the administration of the Parliamentary Grant for Meteorology, instead of making this sum a charge on the Meteorological Grant. The continuance of the observatories could, however, only be undertaken on a guaranteed income of £1000 a year. The directors have therefore decided to close the observatories.—*Nature*, September 22, 1904.

Austrian Meteorological Society.—We are glad to learn that on June 5, 1904, the Emperor accorded the Austrian Meteorological Society permission to use the prefix "K.K.," which is equivalent to "Royal Imperial." The official designation of the Society is now the "K.K. Oesterreischische Gesellschaft für Meteorolgie."

Cairo Observatory.—On January 1, 1904, the Observatory which has hitherto been situated at Abbassia, on the north side of Cairo, was transfered to its new site, at Helwan. This is on the desert plateau above the town of Helwan, about 22 kilometres [14 miles] south of Cairo. The buildings are on the limestone rock, which here forms the surface of the desert, and have an open view over the desert to the north-east and south, while on the west is the Nile Valley, the nearest cultivation being 3 kilometres [2 miles] distant.

At present the main building is occupied, and the Meteorological equipment with complete self-registering apparatus is installed there, also the arrangement for furnishing the noon time signal, which drops the time-balls at Port-Said and Alexandria. There is, besides, a Transit house and an Equatorial house, the house for Magnetic self-registering instruments is not yet completed.

The position of the transit pillar is:—Latitude 29°51′33″ 5 North. Longitude 31°20′30″ 2 East of Greenwich. This latter value depends on the "Venus Station" on the Mokattam Hills at Cairo, being longitude 31°16′ 33″ 6 East of Greenwich.

The altitude of the cistern of the barometer above Mean Sea Level at Alexandria is 115·6 metres.—H. W. HUMPHREYS, *Act. D.-G.*—Survey Department, Public Works Ministry, Cairo, Egypt, *July*, 1904.

Meteorology in Japan.—We have received the first number of a new series of publications entitled the *Bulletin of the Central Meteorological Observatory of Japan*. The Bulletin is not intended to be published periodically, but it is proposed to issue the successive numbers at suitable intervals. This publication chiefly contains the results of researches on Meteorology and allied sciences made by the members of the Tokio Observatory. It is intended that observations and their discussions on special subjects, which are not included in the routine work of the service will be published in the Bulletin.

The first number contains four papers, viz. 1. "Observations of the earth temperature at Tokio," by W. Oishi (16 pp. and plate); 2. "Temperature moyenne annuelle de la surface de la mer dans l'Océan Pacifique Occidental," by Y. Wada (21 pp. and 13 plates); 3. "The epochs of the first Ice in Japan for 1902," by T. Okada (3 pp. and Map); 4. "Evaporation in Japan," by T. Okada (31 pp. and 2 plates).

THE PRINCIPAL CAUSES OF RAIN.

By the Hon. F. A. ROLLO RUSSELL, F.R.Met.Soc.

[Read May 18, 1904.]

The present paper is a sequel to the discussion of the Causes of Haze which has been already brought before the Society in three contributions.

In considering the Causes of Rain, and especially the ordinary phenomena connected with bad weather in England, I was surprised to find that to a very great extent the rainy day is dependent on conditions similar to those which, apart from diurnal changes, produce an excess of haze. These conditions I intend to state with as little detail as possible when dealing with the prevalent type of weather during the approach of a cyclonic disturbance from the west.

The chief causes of rain are only four, but several of these are often in co-operation.

I. A very simple mode of production, one which is only too familiar in the west of England, Scotland, and Ireland, is the forced ascent of moist air by the slopes of mountains. The expansion of the air consequent on ascent causes a fall of temperature, which reduces the mixed air and vapour below the dew-point, and creates first a cloud, and then, with increased ascent and often with increased radiation, rain. The amount of cloud and rain is in some degree proportionate to the height of the hill and the amount of vapour in the air, and is of course extremely large in moist tropical climates.

Good examples of this simple cloud formation may be noticed at the following places, all of which I have seen :—

1. The Cliffs of Hoy, in the Orkneys.

2. Slieve League and other high crags on the coast of Western Ireland. There heavy clouds gather, sometimes forming as far as half a mile out at sea, as the Westerly current begins to rise owing to the pressure in front of it.

3. The Downs of the Isle of Wight above Ventnor, between Ventnor and Shanklin, where rain often falls from Bonchurch to Luccombe, while fine weather prevails at Sandown, when a Southerly wind is blowing.

4. The South Downs of Sussex, where with certain winds and a moist air the ridge is enveloped with mist, while the weather north and south is comparatively clear.

5. The hills of the Isle of Purbeck, where rain is much more frequent than on the level ground eastwards and at Bournemouth.

6. The low hills of Norfolk, which produce in their vicinity a slightly increased rainfall.

7. The hills of Skye and other Western Islands.

8. The hills near the head of Loch Earn in Scotland, where rain with Westerly winds is much more frequent and heavy than at the east or lower end.

9. Blackdown and Hindhead in Surrey, where the rainfall is larger and more frequent than on the lower ground.

The rainfall due to the forced lift of air is in many localities enor-

mous, and ranges from an inch or two of excess in the case of hills 200 or 300 feet high to an excess of at least 500 inches in the Khasia Hills of Bengal.

II. The second cause of rain is similar to the first, but has not, so far as I know, been anywhere dwelt upon. A mass of air invades rather suddenly another mass moving from an opposite direction and maintains its flow below the opposing current which it displaces. If the lower current be, for instance, a cool North-easterly opposing and displacing a South-westerly wind, as sometimes happens in warm summer weather, the lower opposing mass acts like an advancing mountain causing pressure and the ascent of the South-westerly mass in front of it,—in fact, a local lifting of the whole South-westerly current above the upper surface of the North-easterly. Hence heavy precipitation and severe storms, greatly aggravated by the mixture of the winds, as will be presently described.

III. The third cause is the ascent of more or less moist air through heavier and colder air to a height where condensation of vapour takes place, increased radiation of heat towards space, and often electrical developments producing further condensation, increase of temperature, and renewed ascent with the same results. The reactions and phenomena are complex, depending on the relative temperature and moisture of the lower and upper air, on the electrical state, and on the currents of wind prevailing at the time; the resulting phenomena consequently greatly differ from one another.

The ascent of warm moist air producing thunderstorms or heavy showers is very greatly promoted by the opposition of currents near the earth's surface, which at the meeting-place ascend in columns. These storms are often preceded by thick haze, unlike the storms resulting from the mere ascent of heated or moist air in a single current.

IV. The fourth cause, the one which I wish specially to bring forward, is the mixture of currents of air from different directions. Until some time after completing the investigation of the causes of the haze already alluded to, I had never been able to understand the production of the commonest of all kinds of bad weather in England, the rainy days with South-east, South, and South-west winds.

There appeared to be no reason why a South-east wind coming from the drier and warmer, or drier and colder, continent should almost invariably, in a common type of barometric distribution, cause dense cloudiness and continuous rain.

Some years of observation of the direction of upper currents, as shown by high clouds, has now led to results which explain to some extent the curious certainty of the pre-cyclonic rains which so often afflict this country, as for instance, very notably, in the winter which has just passed.

It appears that when the wind backs to a Southerly point, when the cirrus streamers, cirrostratus, or cirrovelum are seen in the south-west and gradually extend over the sky, the upper current maintains to the full its Westerly direction; and while the lower current eventually reaches South or South-east in its backing, and tends towards the cyclonic centre,

the upper continues to blow somewhat outward from the cyclonic centre.

The bad weather generally begins soon after the difference between the upper and lower currents amounts to between one-eighth and one-quarter of the circle. The difference of at least an eighth is often indicated by the appearance of a wavy or ripple cloud, usually cirrostratus, and this cloud may therefore well be taken as a signal of approaching bad weather.

Almost invariably I have found that when the rain clears off, and the blue sky becomes again visible, the lower and upper currents have nearly approached each other; usually the wind has veered from South-east or South to South-west or West-south-west, and the upper has backed a little towards the South, so that on the clearing up, when the cyclone is passing away, the upper current is often more Southerly than the lower. Conversely, any movement of approach of the two currents towards the same direction is followed by finer weather, and again any considerable movement apart by rain.

The backing wind, and the appearance of ripple cloud or an ominous form of cirrostratus, and often either a very transparent lower air or a hazy thickening, I have found much more useful as local signs of coming rain and wind than the barometer. The barometer is often still moving upwards or steady when the change begins, and does not fall till after the commencement of rain.

So frequent is the association of rain with differing currents, and so usual is fine weather with agreeing currents or variable airs, unless very moist, that in nine cases out of ten rain may be taken as a sign of wind-differences, and, as a rule, wind-differences between South-east and North on the west side may be taken as signifying unsettled weather.

In the paper read in December 1901 the following passage occurs: "Haze and Fog are commonly caused by the mixture of currents of different temperatures. These currents may be local or general, high or low. Thick haze or fog, not dependent on differing currents, is rare, but differing currents frequently come into contact without producing haze or fog, and fairly clear weather under opposite currents is not uncommon. A fog may generally be taken *ipso facto* as evidence of the existence in the neighbourhood of a conflict of currents, and prevalent fog or haze commonly signifies that a different wind exists at a high level from that on the surface or at a slight elevation."[1]

With the necessary modifications, some such account might be given of the conditions for the prevalence of rainy weather. But the conditions for rain are dependent more on the opposition or difference of currents at a high level in the upper air. The haze produced in the sky is less dusty and more watery, more free to radiate towards space, and more affected by electrical charges.

I hope on some future occasion to discuss more fully the observations of the upper currents on which this paper is based, and the relation of weather to the relative directions of wind.

Other causes of rain less frequent than those mentioned are the mixture of currents differing in temperature near the earth's surface, the sinking of a cold upper air into rather moist and warmer lower air, the

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. 28, p. 23.

cooling of moist currents moving into higher latitudes, radiation from high clouds causing congelation and descent of hail, snow, or cold rain, through thick clouds at a higher temperature, and lastly the sudden descent of cold upon warm moist air.

DISCUSSION.

Mr. D. W. HORNER said that he had particularly noticed the heavy rains that frequently occurred with South-east winds, with the upper clouds moving from the westward. The upper current invariably overcame the lower, and even when the clouds became extremely thin, so that patches of blue sky could be seen between, the rain still continued heavily. Often at other times when the lower clouds were heavy the rainfall was but slight.

Mr. H. SOUTHALL remarked that in his district when sometimes the clouds were very heavy and there was every appearance of rain not much came of it, but afterwards he had heard of heavy rain having fallen in the mountainous districts of Wales and Cumberland. No doubt condensation there was caused by the colder soil at those higher elevations.

Mr. F. GASTER said that he agreed with the main decisions of the paper, but thought it needed careful reading before attempting to discuss it. He had always been perplexed why such heavy rain frequently occurred with an Easterly wind, and thought Mr. Russell's explanation was an excellent one. The suggestion of the mingling of the two currents, and the Easterly wind at the surface forcing the Westerly current into a higher level, threw a great deal of light on the subject.

THE PRESIDENT (Capt. D. WILSON-BARKER) said the Society owed thanks to Mr. Russell for inviting discussion on such an important subject. Some special points called for particular attention, notably the question of the intermingling of masses of air of different temperatures.

The Hon. F. A. R. RUSSELL, in reply, said that the effects of a mixture of winds were complicated, and led to results which were frequently not in accord with theoretical anticipation. Much work had been done, especially in Germany, in calculating the results of mixture in various conditions of temperature and moisture, and on the whole the conclusion was that mixture was one of the least effective causes of rain. But as a matter of fact and observation, mixture is often found to produce very considerable rainfall, and to be a common factor of the rainy day. Helmholtz found from a comparison of the wind velocity and length of waves in water and in air that wave motions are a very important element in the mixture of different layers of the atmosphere. A wind of 10 metres a second would cause a water wave of about 0·21 metre in length, or an air wave of 549·6 metres, assuming the extreme case where the store of energy of the wave is equal to that of the straight-lined motion along a plane surface. Air waves may be 2 to 5 kilometres long in a fresh breeze, and in great storms even 20 to 30 kilometres, with a height of several hundred metres. It would be interesting to ascertain, if possible, the height of air waves in various conditions of wind by direct observation. The rainfall producible by the lifting of moist air several hundred metres must be considerable. There are other secondary effects due to mixture of opposing or different currents which may account for the excess of the observed over the theoretical rainfall.

MONTHLY RAINFALL AT THE ROYAL OBSERVATORY, GREENWICH, 1815–1903.

By WILLIAM CARPENTER NASH, late of the Royal Observatory, Greenwich.

[Read May 18, 1904].

In undertaking the onerous task of drawing up an authoritative table of rainfall for the long period embraced in the Observatory series, it appeared necessary at the outset to inquire fully into the circumstances relating to the early history of the register. For several years prior to the establishment of the regular meteorological service at the Royal Observatory in 1841, a Meteorological Journal had been kept there (unofficially) by Mr. Belville and other members of the staff. This Journal practically begins in the year 1811, but it was not until December 1814 that rainfall began to be observed. No information is given in the Journal with regard to the position of the gauge, which is incidentally referred to here and there in the register as "Troughton's." Its position, however, appears to be defined by the following statement prefixed by the Astronomer-Royal (the late Sir George Airy) to a manuscript table of rainfall from 1815 to 1850, preserved in the Royal Observatory records: "To 1833 or *thereabouts* the rain-gauge was in the front Court, on a small plot of grass near the N.E. Dome; from that time to 1840 on the leads of the Library.[1] The readings since 1840 are those of rain-gauges on the ground in the Magnetic Grounds."

The observations were made at first with considerable regularity, but after Mr. Belville had changed his residence from the Observatory to the town of Greenwich in 1822, they were made less regularly, as his attention seems to have been engrossed by his own private journal at Park Row. It does not appear, however, that Mr. Belville considered the Observatory journal as in any sense an official document, and in the Belville Journals (now the property of the Royal Meteorological Society) the Observatory observations made by him are included. Although the Observatory journal was partly in abeyance from 1822 to 1826 it would appear that the rain-gauge was never removed from the Observatory, and that the references to rainfall in the Belville Journals are entirely based upon Observatory records until 1828, when Mr. Belville commenced an independent series of rainfall observations at his private residence (then Park Terrace, Greenwich). After 1830 the observations for the journal at the Observatory were mainly made by Mr. Rogerson.[2]

In 1841, upon the establishment of the Meteorological Department under the conduct of Mr. Glaisher, a Crosley self-registering gauge was mounted in the grounds in January for daily observation, followed in February by an eight-inch cylinder-gauge of the ordinary construction for monthly measurement. The original six-inch "Troughton" gauge was retained in its position on the roof of the Library, at the height of

[1] 22 feet above the ground.

[2] It is interesting to note that Mr. Rogerson also kept a private journal from 1834 to 1853 at his residence at Crooms Hill, Greenwich, and that his observations were printed monthly in the *Nautical Magazine*.

22 feet above the ground, and other gauges were also introduced at greater elevations. The monthly gauge continued to be the standard for reference until March 1861, when another gauge of similar construction and dimensions was mounted by its side, to be used for daily observation. [The introduction at this time of graduated measuring glasses marked a considerable advance in accuracy of measurement.] At the beginning of 1899, on account of the extension of the Observatory buildings, the standard gauge was shifted to a more exposed situation 400 yards east of its former position, check-gauges being retained in the Observatory grounds.

The monthly values given in Table I. are based upon the records given by the gauges specified in the foregoing statements, attention being given to the following notes relating to necessary corrections, etc.

1820. February.—"0·60 in." marked "uncertain" in journal, the gauge proving defective.

1820. March.—No record. "1·50 in." adopted by Mr. Glaisher.

1824. June 11.—"An accident to the gauge prevented its ['record'] being carefully ascertained." Monthly amount taken as entered.

1829. December.—Only one entry (0·08 in.), but in the weather notes several entries relating to snow appear between December 19 and 29. On 28th, snow noted "3 inches deep." Next rain entry in journal is on January 7, 1830, "0·65 in." noted as "in part melted snow." It is considered that three-fifths of this amount should belong to the December fall, and the record has therefore been increased by "0·40 in." The Cobham record is 0·42 in.

1831. November.—Rain left in gauge and measured with December amount. Divided proportionally by reference to Belville's record.

1832. February.—Left till end of March: divided proportionally by reference to Belville's record.

1832 to 1840 (inclusive).—All records considered to have been made at the height of 22 feet above the ground: reduced to ground level using the proportion established by comparative records made between 1841-1850. [1832 included on the authority of Belville's record.] The corrected values are printed in *italics*.

1855. August.—Left till end of September: divided proportionally by reference to the record given by another gauge.

TABLE I.—Monthly Rainfall at the Royal Observatory, Greenwich, from 1815 to 1903.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1815	·78	1·20	2·00	2·47	2·14	1·65	1·57	1·83	1·07	2·39	1·37	2·05	20·52
1816	1·90	1·47	1·71	1·94	1·95	2·19	3·91	2·30	1·86	2·61	2·74	2·82	27·40
1817	2·85	1·19	1·90	·06	4·12	1·54	3·86	2·53	·81	2·39	1·80	3·53	26·58
1818	1·73	1·89	3·45	2·99	2·53	·60	·69	·07	3·78	1·89	2·49	1·34	23·45
1819	2·12	2·67	1·58	2·82	2·98	2·28	2·00	·36	3·13	2·13	2·69	3·48	28·24
1820	1·73	·60	(1·50)	1·48	3·57	2·11	4·38	1·70	2·23	2·64	1·76	1·57	25·27
1821	2·18	·04	3·45	1·82	2·22	2·21	2·82	1·92	3·40	2·42	4·33	4·72	31·53
1822	·55	·98	1·39	2·56	1·90	·80	4·07	1·81	1·37	3·60	3·66	2·26	24·95
1823	1·36	3·17	1·36	1·75	·74	1·14	3·30	2·68	·89	3·96	1·55	2·48	24·38
1824	·94	2·34	1·69	1·89	3·77	3·51	1·81	3·95	3·21	2·44	3·88	3·55	32·98
1825	1·03	·86	1·30	1·75	2·97	·74	·10	2·48	2·56	2·69	2·85	2·92	22·25
1826	·30	1·66	1·66	·97	2·47	·97	2·44	1·69	3·07	1·74	2·46	1·28	20·71
1827	1·06	·60	2·40	1·16	2·39	·59	1·25	1·05	3·51	3·87	1·17	3·33	22·38
1828	3·87	1·04	·86	2·17	1·47	1·85	6·43	3·75	2·41	1·41	·85	2·33	28·44
1829	·36	1·17	·60	4·35	·45	1·46	3·78	4·13	3·27	1·67	1·32	·48	23·04
1830	1·05	2·28	·28	2·84	1·96	2·38	1·69	3·55	3·24	·66	3·09	1·20	24·22
1831	1·00	2·84	2·03	1·55	1·52	1·91	3·09	1·77	1·97	4·97	1·45	2·31	26·41
1832	*1·28*	*·37*	*1·22*	*·40*	*1·55*	*3·30*	*·70*	*3·44*	*·46*	*2·48*	*1·87*	*1·19*	*18·26*
1833	*1·24*	*4·00*	*1·03*	*1·31*	*·25*	*2·03*	*1·65*	*1·71*	*1·88*	*1·29*	*2·60*	*4·85*	*23·84*
1834	*3·33*	*·44*	*·69*	*·50*	*·97*	*1·50*	*5·32*	*3·27*	*·87*	*·47*	*1·50*	*1·22*	*20·08*
1835	*·68*	*2·88*	*2·80*	*1·04*	*3·00*	*2·45*	*·28*	*1·10*	*4·15*	*4·20*	*2·37*	*·50*	*25·45*
1836	*2·02*	*2·00*	*2·37*	*2·71*	*1·32*	*1·12*	*1·70*	*2·63*	*3·13*	*4·17*	*2·67*	*2·00*	*27·84*
1837	*2·95*	*1·83*	*·55*	*1·21*	*·98*	*1·10*	*1·56*	*4·52*	*1·25*	*2·46*	*1·88*	*1·43*	*21·72*
1838	*·91*	*2·18*	*1·09*	*·58*	*1·50*	*5·07*	*1·98*	*1·02*	*2·88*	*1·98*	*3·50*	*1·90*	*24·59*
1839	*1·49*	*1·70*	*1·94*	*1·44*	*1·66*	*1·87*	*3·72*	*2·71*	*4·85*	*1·90*	*4·84*	*2·66*	*30·78*
1840	*2·60*	*1·31*	*·30*	*·10*	*2·03*	*1·50*	*1·63*	*1·08*	*2·84*	*1·62*	*3·16*	*·50*	*18·67*
1841	2·11	1·32	1·35	1·92	2·06	2·70	3·60	2·20	3·95	5·95	3·70	2·40	33·26
1842	1·02	1·05	1·90	·43	2·09	·95	2·96	1·78	3·99	1·41	4·25	·74	22·57
1843	1·35	2·39	·51	1·72	3·75	1·30	2·42	3·62	·46	4·25	2·30	·40	24·47
1844	2·42	2·32	2·30	·35	·30	1·56	2·18	1·71	1·19	4·01	4·50	·36	23·20
1845	2·40	·93	1·51	·55	2·21	1·89	1·85	3·10	2·12	1·38	2·40	2·00	22·34
1846	2·82	1·47	·88	3·05	1·50	·50	1·50	4·00	1·79	5·13	1·52	1·13	25·29
1847	1·38	1·39	·77	·99	1·40	1·50	·67	1·95	1·56	2·00	2·00	2·00	17·61
1848	1·20	2·60	3·10	3·44	·40	3·50	1·98	4·25	2·38	3·50	1·20	2·55	30·10
1849	1·50	2·30	·60	1·98	3·70	·30	2·90	·45	3·25	2·70	1·50	2·40	23·58
1850	1·20	1·40	·40	2·25	2·30	1·00	2·82	1·70	1·35	1·58	2·18	1·35	19·53
1851	2·70	1·25	4·05	2·30	·80	1·75	4·20	2·60	·50	2·18	·65	·55	23·53
1852	3·60	·90	·17	·49	1·90	4·60	2·25	4·35	3·80	3·75	6·00	2·20	34·01
1853	2·11	1·48	1·50	3·21	1·50	2·75	5·48	2·75	2·23	4·23	1·95	·80	29·99
1854	1·40	1·21	·32	·59	3·51	·91	1·75	2·61	·98	2·42	1·90	1·41	19·01
1855	1·47	1·00	1·98	·09	1·80	·85	5·25	1·40	1·95	5·20	1·50	1·10	23·59
1856	2·63	1·10	1·10	2·28	3·45	1·60	·90	2·42	2·80	1·91	1·25	1·83	23·27
1857	2·60	·20	·83	1·40	·33	2·70	1·10	2·50	3·40	4·20	1·35	·55	21·16
1858	·75	1·70	·80	2·25	2·00	1·20	3·00	1·50	·86	1·44	·50	1·70	17·70
1859	·80	·86	1·35	2·17	2·35	1·40	3·30	1·13	3·80	3·60	2·90	2·17	25·83
1860	1·81	1·10	1·86	1·00	3·90	5·80	2·80	3·68	3·10	1·60	2·50	2·75	31·90
1861	·55	1·80	2·15	·83	1·79	1·90	2·20	·57	1·46	·88	5·07	1·25	20·45
1862	1·79	·46	3·54	2·82	2·84	1·93	1·66	3·01	1·61	4·07	1·00	1·59	26·32
1863	2·71	·50	·70	·45	1·25	3·91	·88	1·82	2·95	1·82	1·59	1·08	19·66
1864	·88	·76	2·53	·82	2·00	·92	·27	1·31	2·76	1·06	2·57	·50	16·38
1865	3·32	1·75	·85	·40	4·37	2·45	2·27	3·97	·16	5·90	2·39	·87	28·70
1866	3·68	4·03	1·63	2·44	1·94	3·64	1·62	2·42	3·90	2·09	1·48	1·85	30·72

MONTHLY RAINFALL AT THE ROYAL OBSERVATORY—*Continued.*

YEARS.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1867	2·79	1·22	2·28	2·16	2·34	1·77	5·81	2·64	2·92	2·14	·42	1·97	28·46
1868	4·19	1·28	1·07	2·08	1·67	·47	1·06	2·61	1·52	2·59	1·16	5·45	25·15
1869	2·92	2·34	1·41	1·01	3·43	1·15	·55	1·21	3·08	1·77	2·38	2·77	24·02
1870	1·49	·54	2·05	·28	·47	·39	2·01	2·02	1·63	3·34	1·20	3·13	18·55
1871	2·05	1·09	1·10	3·03	·68	2·95	3·25	·86	4·12	1·37	·57	1·23	22·30
1872	3·63	·77	2·13	·98	3·09	1·64	2·36	2·70	1·39	4·34	2·92	4·07	30·02
1873	2·45	1·93	1·33	·61	1·49	2·56	1·85	3·18	2·52	2·55	2·58	·31	23·36
1874	1·00	·94	·45	1·35	·42	2·42	2·59	1·44	2·22	3·58	1·85	1·69	19·95
1875	2·99	·82	·56	1·55	1·46	2·28	5·28	2·28	2·66	4·13	2·90	1·06	27·97
1876	1·11	1·50	2·32	1·27	1·13	1·08	·67	2·01	2·58	1·61	3·06	5·76	24·10
1877	4·35	1·71	2·23	3·35	1·38	·68	2·46	2·90	1·15	1·78	3·53	1·76	27·28
1878	·87	1·10	1·06	4·31	4·29	4·57	·31	5·38	·82	1·66	3·45	1·16	28·98
1879	2·59	3·82	·60	2·60	3·36	4·29	3·72	5·19	2·87	·76	·91	·65	31·36
1880	·26	2·36	·60	2·20	·50	2·26	3·81	·98	4·00	7·65	2·06	3·00	29·68
1881	1·66	2·45	1·83	·62	1·61	1·86	2·14	3·89	2·19	2·71	2·27	2·49	25·72
1882	1·35	1·15	1·14	2·40	1·37	2·36	2·45	1·16	2·41	5·42	2·20	1·77	25·18
1883	1·69	2·89	·78	1·70	1·71	1·34	2·00	·71	3·82	1·59	2·85	·83	21·91
1884	1·77	1·50	1·37	1·11	·96	2·24	1·77	·67	2·09	1·04	·99	2·54	18·05
1885	1·42	2·33	1·50	2·05	2·11	1·67	·50	1·32	3·73	3·41	2·83	1·13	24·00
1886	3·68	·56	1·14	1·26	4·23	·44	2·51	1·12	1·24	1·41	3·02	3·60	24·21
1887	1·15	·53	1·35	1·75	1·73	1·23	1·29	2·35	2·21	1·03	3·77	1·47	19·86
1888	·89	·89	2·78	1·51	·65	3·36	6·75	3·73	·73	1·30	4·00	·92	27·51
1889	·84	2·19	1·32	1·85	3·30	2·07	2·06	1·81	1·69	3·93	·78	1·44	23·28
1890	2·08	1·04	1·96	1·77	1·34	2·54	4·50	2·54	·65	1·19	1·48	·77	21·86
1891	1·56	·05	2·14	·72	2·69	·96	3·39	3·72	·82	4·32	2·00	2·67	25·04
1892	·38	1·69	1·09	1·42	1·66	2·27	1·53	3·03	2·01	3·88	2·21	1·14	22·31
1893	1·45	2·72	·43	·12	·53	·82	3·33	1·25	1·29	4·16	1·83	2·19	20·12
1894	3·09	1·59	·73	1·44	1·52	2·04	3·26	3·03	1·25	3·99	3·00	1·95	26·89
1895	1·62	·22	1·43	1·25	·45	·21	3·39	2·14	·93	2·69	2·89	2·51	19·73
1896	·64	·36	3·00	·56	·27	1·94	1·06	2·06	5·54	2·80	1·19	3·00	22·42
1897	1·62	2·38	3·35	1·62	1·25	1·93	·73	2·86	2·70	·48	1·07	2·14	22·13
1898	·65	1·19	1·40	·93	2·64	1·75	1·34	·86	·30	3·15	2·41	2·23	18·85
1899	2·53	1·93	·61	3·00	1·65	·76	1·74	·35	2·23	2·34	3·73	1·46	22·33
1900	2·28	3·58	·92	·92	1·37	2·81	1·41	2·03	1·14	1·55	2·02	2·28	22·31
1901	·76	·87	2·17	1·81	1·79	1·49	1·72	2·03	1·35	2·60	·67	3·03	20·29
1902	·64	·79	1·36	·42	3·33	3·10	1·09	2·93	1·65	1·24	1·29	1·50	19·34
1903	2·13	1·37	2·20	1·85	1·95	6·07	5·27	4·82	2·24	4·44	1·93	1·27	35·54
Means	1·80	1·52	1·52	1·61	1·95	1·97	2·45	2·33	2·25	2·72	2·29	1·95	24·36

The values given for the years 1867 and 1868 in the foregoing table are those printed in the Greenwich Volumes, and are the values usually received and adopted. But by comparison with the records given by neighbouring gauges, and also with those obtained at Camden Square, it would seem that several of the monthly values are too large, and that the values given by the adjacent monthly gauge are more reliable. The following are the values given by the monthly gauge in those years :—

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1867	2·80	1·21	2·30	2·10	2·20	1·51	5·30	2·50	2·61	1·93	0·42	1·70	26·58
1868	3·69	1·20	1·00	1·76	1·34	0·30	0·71	2·31	1·37	2·35	1·05	4·70	21·78

If these numbers were used instead of those already given, the averages at the foot of the table would be diminished by ·01 in. in each of the months April, June, July, September, November, and December, and for the year by ·06 in. It is probable, however, that it may be considered desirable (as the effect produced is somewhat small) not to alter these numbers, but simply to draw attention to the discrepancy.

In Table II. the annual values of the rainfall are given, and the percentages of the average amount, which could not be conveniently included in Table I. In addition, the rainy days are also given for as many years as daily observations were completely made, but in several cases the values for some of the early years are subject to suspicion.

TABLE II.—ANNUAL RAINFALL AT THE ROYAL OBSERVATORY, GREENWICH, FROM 1815 TO 1903, AND NUMBER OF RAINY DAYS FOR CERTAIN YEARS; WITH ANNUAL PERCENTAGES OF THEIR AVERAGES.

Years.	Rainfall.		Rainy Days.		Years.	Rainfall.		Rainy Days.		Years.	Rainfall.		Rainy Days.	
	Amount.	Percentage of average, 1815-1903.	Number.	Percentage of average, 1841-1903.		Amount.	Percentage of average, 1815-1903.	Number.	Percentage of average, 1841-1903.		Amount.	Percentage of average, 1815-1903.	Number.	Percentage of average, 1841-1903.
	in.	%		%		in.	%		%		in.	%		%
1815	20·52	84	156	99	1845	22·34	92	172	109	1875	27·97	115	152	97
1816	27·40	112	195	124	1846	25·29	104	158	100	1876	24·10	99	167	106
1817	26·58	109	195	124	1847	17·61	72	157	100	1877	27·28	112	186	118
1818	23·45	96	142	90	1848	30·10	124	214	136	1878	28·98	119	167	106
1819	28·24	116	148	94	1849	23·58	97	152	97	1879	31·36	129	185	117
1820	25·27	104	123	78	1850	19·53	80	141	90	1880	29·68	122	160	101
1821	31·53	129	149	95	1851	23·53	97	140	89	1881	25·72	106	156	99
1822	24·95	102	121	77	1852	34·01	140	152	97	1882	25·18	103	180	114
1823	24·38	100	116	74	1853	29·99	123	184	117	1883	21·91	90	173	110
1824	32·98	135	140	89	1854	19·01	78	145	92	1884	18·05	74	150	95
1825	22·25	91	...	...	1855	23·59	97	144	91	1885	24·00	99	166	105
1826	20·71	85	...	...	1856	23·27	96	145	92	1886	24·21	99	163	103
1827	22·38	92	...	...	1857	21·16	87	121	77	1887	19·86	82	143	91
1828	28·44	117	...	...	1858	17·70	73	112	71	1888	27·51	113	165	105
1829	23·04	95	...	...	1859	25·83	106	145	92	1889	23·28	96	159	101
1830	24·22	99	...	...	1860	31·90	131	191	121	1890	21·86	90	162	103
1831	26·41	108	...	...	1861	20·45	84	147	93	1891	25·04	103	178	113
1832	18·26	75	...	...	1862	26·32	108	169	107	1892	22·31	92	170	108
1833	23·84	98	...	...	1863	19·66	81	134	85	1893	20·12	83	154	98
1834	20·08	82	...	...	1864	16·38	67	116	74	1894	26·89	110	192	122
1835	25·45	104	...	...	1865	28·70	118	146	93	1895	19·73	81	158	100
1836	27·84	114	...	...	1866	30·72	126	173	110	1896	22·42	92	161	102
1837	21·72	89	...	...	1867	28·46?	117	163	103	1897	22·13	91	169	107
1838	24·59	101	...	...	1868	25·15?	103	144	91	1898	18·85	77	142	90
1839	30·78	126	...	...	1869	24·02	99	147	93	1899	22·33	92	141	90
1840	18·67	77	...	...	1870	18·55	76	129	82	1900	22·31	92	165	105
1841	33·26	137	176	112	1871	22·30	92	162	103	1901	20·29	83	123	78
1842	22·57	93	138	88	1872	30·02	123	197	125	1902	19·34	79	159	101
1843	24·47	100	156	99	1873	23·36	96	144	91	1903	35·54	146	179	114
1844	23·20	95	142	90	1874	19·95	82	139	88					
										Average	24·36	...	157·5	...

The rainfall average is based upon the observations for the 89 years, 1815-1903; and that for the rainy days upon the results for the 63 years, 1841-1903.

Annual averages for different periods deduced from Table II. are—

	Rainfall. in.	Rainy Days.
30 years, 1815–1844	24·92	...
30 years, 1845–1874	24·08	152·8
29 years, 1875–1903	24·08	162·9
26 years, 1815–1840	24·77	...
30 years, 1841–1870	24·34	151·8
40 years, 1841–1880	24·88	155·3
50 years, 1841–1890	24·54	156·6
60 years, 1841–1900	24·15	157·6
63 years, 1841–1903	24·19	157·5
89 years, 1815–1903	24·36	...
and for shorter periods:—		
6 years, 1815–1820	25·24	159·8
10 years, 1821–1830	25·49	...
10 years, 1831–1840	23·76	...
10 years, 1841–1850	24·19	160·6
10 years, 1851–1860	25·00	147·9
10 years, 1861–1870	23·84	146·8
10 years, 1871–1880	26·50	165·9
10 years, 1881–1890	23·16	161·7
10 years, 1891–1900	22·21	163·0

From an inspection of these numbers it is evident that with so variable an element as rainfall a consistent average can scarcely be produced even with fifty or sixty years' observations. A long-continued run of wet or dry years will seriously affect the average in short periods. This is well shown in the ten-year averages given above. A run of eight consecutive wet years (1875-1882) yielded an aggregate fall of 220·27 in. on 1353 days, with means for the period of 27·53 in. and 169·1 days per annum. A similar run of eight consecutive dry years, extending from 1895 to 1902, produced an aggregate fall of 167·40 in. on 1218 days, the annual means for this period being 20·92 in. and 152·2 days respectively; the total difference in amount between these periods exceeding the rainfall for two average years.

Before quitting the subject of the annual rainfall it may be interesting to give a few particulars relating to extreme falls.

Greatest annual fall in whole period (1815-1903)	35·54 in. in 1903
Least annual fall in whole period ,,	16·38 in. in 1864
Greatest annual number of rainy days (1841-1903)	214 in 1848
Least annual number of rainy days ,,	112 in 1858

TABLE III.—Large and Small Annual Falls.

Large Annual Falls (exceeding 29 in.).			Small Annual Falls (less than 20 in.).		
Year.	Amount. in.	No. of Rainy Days.	Year.	Amount. in.	No. of Rainy Days.
1821	31·53	149?	1832	18·26	...
1824	32·98	140?	1840	18·67	...
1839	30·78	...	1847	17·61	157
1841	33·26	176	1850	19·53	141
1848	30·10	214	1854	19·01	145
1852	34·01	152	1858	17·70	112
1853	29·99	184	1863	19·66	134
1860	31·90	191	1864	16·38	116
1866	30·72	173	1870	18·55	129
1872	30·02	197	1874	19·95	139
1879	31·36	185	1884	18·05	150
1880	29·68	160	1887	19·86	143
1903	35·54	179	1895	19·73	158
			1898	18·85	142
			1902	19·34	159

.The monthly values will now be considered. In Table IV. a summary is given of the monthly averages and extremes of rainfall and rainy days.

TABLE IV.—AVERAGE MONTHLY RAINFALL FOR THE 89 YEARS 1815-1903; AND OF THE RAINY DAYS FOR THE 63 YEARS 1841-1903; WITH MONTHLY EXTREMES; DEDUCED FROM THE OBSERVATIONS MADE AT THE ROYAL OBSERVATORY, GREENWICH.

Months.	Rainfall, 1815-1903.						Rainy Days, 1841-1903.				
	Average.	Percentage of Yearly Average.	Maximum.	Year.	Minimum.	Year.	Average.	Maximum.	Year.	Minimum.	Year.
	in.	%	in.		in.						
January	1·80	7·4	4·35	1877	·26	1880	14·8	23	1877	5	1858
February	1·52	6·2	4·03	1866	·04	1821	12·4	22	1893	3	1857
March	1·52	6·2	4·05	1851	·17	1852	13·2	22	1848, 1896	3	1852
April	1·61	6·6	4·35	1829	·06	1817	12·0	21	1848	2	1852
May	1·95	8·0	4·37	1865	·25	1833	12·4	22	1843, 1878, 1898, 1902	3	1848
June	1·97	8·1	6·07	1903	·21	1895	11·6	23	1860	3	1887
July	2·45	10·1	6·75	1888	·10	1825	12·6	26	1888	2	1869
August	2·33	9·6	5·38	1878	·07	1818	12·9	29	1848	5	1864
September	2·25	9·2	5·54	1896	·16	1865	12·3	23	1896	1	1865
October	2·72	11·2	7·65	1880	·47	1834	15·1	27	1853	4	1842
November	2·29	9·4	6·00	1852	·42	1867	14·0	24	1872	5	1867
December	1·95	8·0	5·76	1876	·31	1873	14·2	23	1868	6	1851, 1857, 1873
Year	24·36	100·0	35·54	1903	16·38	1864	157·5	214	1848	112	1858

During the five months January to May, no monthly fall exceeding 4·37 in. was recorded; but in the remaining seven months there were 24 falls exceeding 5 in., distributed in the following proportion:—June, 3; July, 8; August, 2; September, 1; October, 6; November, 2; and December, 2. The principal falls were:—

	in.		in.
1880, October	7·65 on 18 days	1865, October	5·90 on 19 days
1888, July	6·75 ,, 26 ,,	1867, July	5·81 ,, 12 ,,
1828, July	6·43 ,, (?) ,,	1860, June	5·80 ,, 23 ,,
1903, June	6·07 ,, 10 ,,	1876, December	5·76 ,, 22 ,,
1852, November	6·00 ,, 22 ,,	1896, September	5·54 ,, 23 ,,
1841, October	5·95 ,, 22 ,,		

Light monthly falls of rain are spread principally through the nine months January to September, with a decided preponderance in spring. Of falls to a less amount than 0·3 in. per month, 5 have been recorded in the month of April; 4 in February; 3 in each of the months of March, May, and July; 2 in January, June, and September; and 1 in August.

The principal instances of light monthly rainfall were:—

1821, February . .	in. ·04 on 1 day	1825, July	in. ·10 on 1 day
1891, February . .	·05 ,, 4 days	1893, April. . . .	·12 ,, 3 days
1817, April . . .	·06 ,, 4 days	1865, September . .	·16 ,, 1 day
1818, August . . .	·07 ,, 1 day	1852, March . . .	·17 ,, 3 days
1855, April . . .	·09 ,, 4 days	1857, February . .	·20 ,, 3 days
1840, April . . .	·10 ,, (!) ,,		

The distribution of heavy and light rains throughout the year will be readily seen by reference to Table V.

TABLE V.—Distribution of Heavy and Light Monthly Rainfalls through the Year, during the Period 1815-1903.

Months.	Number of Heavy Monthly Falls.			Number of Light Monthly Falls.		
	Exceeding 3 in.	Exceeding 4 in.	Exceeding 5 in.	Less than 0.3 in.	Less than 0.5 in.	Less than 1 in.
January . .	10	2	...	2	4	22
February . .	5	2	...	4	9	27
March . .	7	1	...	3	7	26
April . . .	8	2	...	5	13	27
May . . .	17	4	...	3	10	18
June . . .	13	6	3	2	6	19
July . . .	28	12	8	3	5	13
August . .	24	8	2	1	4	10
September . .	25	5	1	2	5	15
October . .	32	19	6	...	2	5
November . .	20	7	2	...	2	9
December . .	14	5	2	...	7	16
Totals . .	203	73	24	25	74	207

The subject of rainfall has been dealt with so thoroughly by Symons and others that it is probable that no new points have been brought out in the present paper. But it is evident that this is an incomplete inquiry. The daily rainfall, which has already been subjected to analysis to a certain extent by Glaisher, still remains for investigation. I fear, however, that I am in danger of exceeding the limits allotted by the Society, but should be glad to be permitted to continue the subject at some future time. In bringing this inquiry temporarily to a close, I wish to express my thanks to the Astronomer-Royal for his courtesy in allowing me to include the results of the observations contained in the early journals, and for affording me facilities for referring to the Royal Observatory manuscripts. I have also to thank the Council of the Royal Meteorological Society for allowing me to refer to the Belville journals and to make extracts relating to observations of rainfall, which have been of the greatest service.

APPENDIX.

[On account of references being frequently made to the records of Belville's and other gauges in the vicinity of the Observatory, it has been considered desirable to give these records as an appendix to the paper.]

TABLE VI.—Mr. J. H. Belville's Record at Various Places in Greenwich.

[1828 to 1833, February, at Park Terrace; 1833, March, to 1840, August, at Blackheath Road; 1840, September, to 1844, January, at Prior Street; 1844, February, to 1856, June, at Hyde Vale.] (Extracted from *Belville's Journal.*)

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1828	*3·83*	*1·24*	*1·04*	*2·22*	1·47	1·85	6·65	3·51	2·53	1·41	0·85	2·33	28·93
1829	0·37	1·16	0·57	4·79	0·50	1·52	4·35	4·54	3·48	1·64	1·78	0·08?	24·78
1830	2·19	1·46	0·40	3·29	2·12	2·89	1·78	3·88	3·34	0·98	2·85	1·29	26·47
1831	1·18	2·31	2·39	1·93	1·51	2·00	3·11	2·43	3·38	4·27	1·79	2·85	29·15
1832	1·15	0·30	1·08	0·48	1·16	4·16	0·84	3·77	0·65	2·75	1·82	1·77	19·93
1833	0·56	3·69	1·07	2·12	0·61	2·14	1·94	1·64	2·36	1·81	2·94	4·54	25·42
1834	3·06	0·38	0·46	0·41	1·10	1·45	5·39	2·86	0·79	0·53	1·37	0·98	18·78
1835	0·67	2·51	2·64	1·41	3·35	3·14	0·42	0·76	3·33	3·61	1·91	0·49	24·24
1836	2·03	1·83	3·13	3·04	1·22	1·07	1·91	2·56	3·37	5·07	3·18	1·93	30·34
1837	2·94	2·20	0·66	1·52	1·22	1·15	1·61	4·65	1·25	2·61	1·75	1·37	22·93
1838	0·48	1·71	0·85	0·55	1·15	4·26	2·15	1·24	2·59	1·77	3·17	1·76	21·68
1839	1·22	1·62	1·84	1·45	1·72	1·93	3·28	2·42	4·80	1·69	3·97	2·58	28·52
1840	2·55	1·46	0·34	0·12	2·01	1·35	1·70	1·03	2·51	1·40	2·72	0·42	17·61
1841	2·89	0·87	1·08	1·81	1·70	1·76	2·96	2·50	3·62	5·37	3·70	2·14	30·40
1842	0·96	1·09	2·03	0·57	2·22	0·95	2·78	1·38	3·83	1·39	4·29	0·72	22·21
1843	1·25	2·35	0·46	1·73	4·10	1·35	2·79	3·26	0·40	4·15	2·12	0·31	24·27
1844	2·76	2·25	2·98	0·37	0·34	1·48	2·88	1·87	1·24	3·95	4·41	0·41	24·94
1845	2·35	0·99	1·28	0·44	2·29	2·00	1·96	2·79	2·10	1·31	2·31	2·51	22·33
1846	2·81	1·24	1·05	2·90	1·57	0·60	1·76	4·06	1·75	5·09	1·41	1·09	25·33
1847	1·10	1·48	0·76	1·06	1·37	1·37	0·67	1·88	1·76	2·09	1·88	2·00	17·42
1848	1·35	2·80	2·92	3·22	0·23	3·78	2·27	4·43	2·30	3·40	1·06	2·72	30·48
1849	1·75	2·45	0·50	2·40	3·85	0·24	3·07	0·35	3·01	2·70	1·28	2·05	23·65
1850	0·80	1·57	0·23	2·50	2·49	1·09	2·79	1·68	1·55	1·58	2·10	1·37	19·75
1851	2·80	1·05	4·02	2·02	1·03	1·32	4·20	2·69	0·35	2·09	0·76	0·64	22·97
1852	3·74	1·23	0·11	0·42	2·25	4·76	2·22	4·54	4·00	4·18	6·08	2·01	35·54
1853	2·17	0·53	1·01	3·25	1·50	2·63	5·70	2·35	2·32	3·74	1·35	0·45	27·00
1854	1·20	0·90	0·45	0·50	3·21	0·79	1·60	2·66	0·78	2·00	1·30	1·47	16·86
1855	0·36	0·99	1·40	0·18	1·61	0·78	4·93	1·10	1·39	4·94	1·29	1·24	20·21
1856	2·22	1·16	1·07	2·14	3·93	1·70	[End of record]				...	...	...
Means, 1828-1855	1·80	1·56	1·31	1·67	1·75	1·92	2·78	2·60	2·31	2·77	2·34	1·55	24·36

N.B.—Several of the monthly records in 1828 appear to be those made at the Royal Observatory; and in 1829, December, the snow which fell near the end of the month does not appear to have been measured till January 1830. (See note relating to the Observatory record for 1829, December.)

Mr. Belville's station at Park Terrace was about 600 yards N.N.E. of the Observatory.

The station at Blackheath Road was about 1350 yards W.S.W. of the Observatory.

The station at Prior Street was about 715 yards W.S.W. of the Observatory.

And the station at Hyde Vale was about 570 yards S.W. of the Observatory.

TABLE VII.—Mr. Rogerson's Record at Crooms Hill, 1834-1853.
(Extracted from the *Nautical Magazine*.)

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1834	*2·95*	*0·37*	0·60	0·50	0·90	(1·40)	4·85	3·00	0·80	0·44	1·25	1·00	(18·06)
1835	0·60	2·40	2·30	0·94	2·76	2·23	0·25	1·00	3·80	3·85	1·96	0·40	22·49
1836	1·70	1·65	2·00	2·50	1·20	1·05	1·55	2·45	2·96	3·85	2·25	1·65	24·81
1837	2·45	*1·86*	0·45	1·10	0·90	1·00	1·50	4·20	1·15	2·30	1·60	1·20	19·71
1838	0·80	1·85	0·95	0·55	1·40	4·60	1·85	0·95	2·65	1·80	3·00	1·60	22·00
1839	1·25	1·45	1·65	1·35	1·50	1·70	3·44	2·50	4·50	1·75	4·00	2·45	27·54
1840	2·92	1·38	0·33	0·11	2·10	1·50	1·58	1·02	2·65	1·50	2·70	0·45	18·24
1841	2·98	0·98	1·28	1·91	1·81	2·12	4·31	1·70	3·86	5·50	4·02	2·29	32·76
1842	1·07	1·04	2·15	0·51	2·40	1·18	2·74	1·85	4·29	1·56	4·73	0·74	24·26
1843	1·25	2·68	0·52	1·86	4·14	1·27	2·55	4·10	0·44	4·50	2·13	0·31	25·75
1844	3·19	2·89	3·05	0·38	0·32	2·09	3·06	1·94	1·14	4·08	4·70	0·40	27·24
1845	2·48	1·00	1·47	0·70	2·25	2·03	2·04	3·23	2·15	1·35	2·58	2·85	24·13
1846	3·09	1·31	1·03	2·99	1·61	0·67	1·74	5·21	1·92	5·27	1·33	1·18	27·35
1847	1·34	1·67	0·74	0·86	1·25	1·44	0·71	2·33	1·77	2·00	1·97	2·05	18·13
1848	1·43	3·13	3·29	3·46	0·24	3·96	2·35	5·09	2·41	3·62	0·96	2·70	32·64
1849	1·67	2·46	0·45	2·39	4·27	0·32	3·38	0·42	3·22	2·93	1·46	2·13	25·10
1850	1·35	0·99	0·19	2·62	2·47	0·98	2·80	1·79	1·61	1·55	2·47	1·59	20·41
1851	2·86	1·03	4·37	2·50	0·78	1·38	4·38	2·43	0·37	1·44	0·55	0·69	22·78
1852	3·22	1·16	0·12	0·60	1·86	4·54	2·24	4·42	4·04	4·08	6·05	1·97	34·30
1853	2·05	0·87	1·18	[End of record.]			...	...	...	...	...	...	...
Means, 1834-1852	2·03	1·65	1·42	1·46	1·80	1·87	2·49	2·61	2·41	2·81	2·62	1·45	24·62

1834, January and February; adopted. 1834, June; printed in the *Nautical Magazine* as 0·40 in., altered to 1·40 in. 1837, February; adopted.

[Mr. Rogerson's station at Crooms Hill was about ¼-mile west of the Observatory.]

TABLE VIII.—The Rev. George Fisher's Record at the Royal Hospital Schools, 1844-1853 [1849 wanting]. (Extracted from the *Greenwich Observations*.)

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1844	*2·32*	*2·09*	2·87	0·35	0·37	1·82	2·82	1·99	1·23	4·03	4·32	0·42	24·63
1845	2·39	0·88	1·29	0·58	2·16	1·87	1·91	2·88	2·07	1·32	2·37	2·55	22·27
1846	2·66	0·91	0·80	2·76	1·46	0·43	1·60	4·27	1·73	5·14	1·53	1·08	24·37
1847	1·19	1·45	0·62	0·91	1·28	1·54	0·63	2·06	1·61	1·82	1·69	2·01	16·81
1848	1·08	2·72	2·99	3·11	0·39	3·42	1·73	3·68	2·22	3·23	0·97	2·38	27·92
1849	*1·47*	*2·28*	*0·57*	*1·79*	*3·60*	*0·27*	*2·75*	*0·41*	*3·27*	*2·41*	*1·28*	*2·41*	*22·51*
1850	1·30	1·40	0·20	2·10	2·20	0·80	2·80	1·40	1·60	1·50	1·90	1·50	18·70
1851	2·80	1·00	4·10	2·00	0·90	1·20	4·00	2·40	0·40	1·70	0·60	0·60	21·70
1852	3·20	1·00	0·20	0·40	1·80	4·82	2·25	4·20	3·90	3·80	5·80	1·90	33·27
1853	2·13	0·97	0·98	3·02	1·41	2·69	5·36	2·27	2·06	4·46	1·53	*0·80*	27·68
Means, 1844-1853	2·05	1·47	1·46	1·70	1·56	1·89	2·58	2·56	2·01	2·94	2·20	1·57	23·99

1844, January and February; 1849, the whole year; and 1853, December; approximate values deduced from the Royal Observatory records.

[Rev. G. Fisher's station was about ¼-mile N.N.W. of the Observatory.]

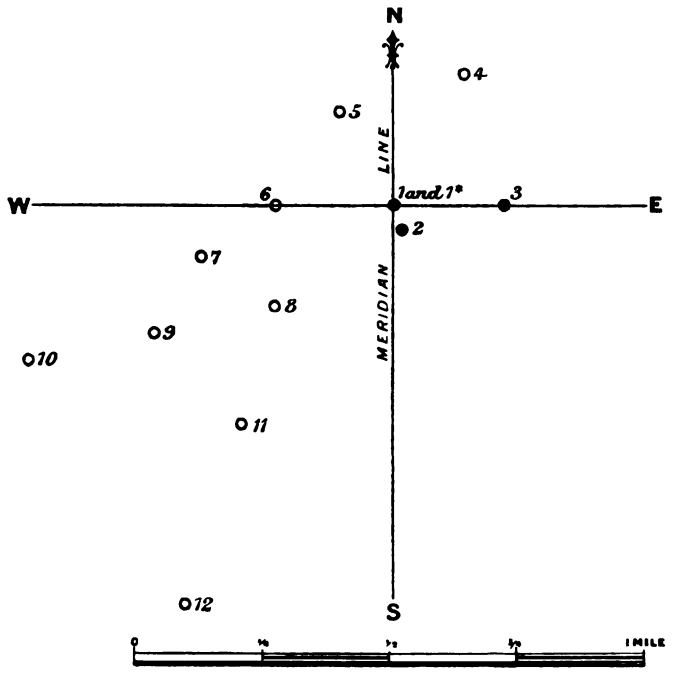


Diagram showing the relative positions of the Rain-gauge Stations in Greenwich and neighbourhood.

INDEX TO THE STATIONS.

1 and 1*. Royal Observatory, Courtyard and Library . . . . 1815 to 1840
2. Royal Observatory, Magnetic Grounds . . . . . 1841 to 1898
3. Royal Observatory, Magnetic Enclosure . . . . . 1899 to 1903
4. Park Terrace (Belville 1) . . 1828 to 1833
5. Royal Hospital Schools (Rev. Geo. Fisher) . . . . . 1844 to 1853
6. Crooms Hill (Rogerson) . . 1834 to 1853
7. Prior Street (Belville 3) . . 1840 to 1844
8. Hyde Vale (Belville 4) . . 1844 to 1856
9. Maidenstone Hill (Ellis) . . 1848 to 1851
10. Blackheath Road (Belville 2) . 1833 to 1840
11. Dartmouth Place, Blackheath (Glaisher 2) . . . . . 1875 to 1893
12. Dartmouth Terrace, Lewisham (Glaisher 1) . . . . . 1851 to 1859

TABLE IX.—MR. W. ELLIS'S RECORD AT MAIDENSTONE HILL, FROM 1848–1851.
(Extracted from the *Registrar General's Quarterly Reports.*)

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1848	1·1	3·1	3·3	3·2	0·07	4·0	2·3	4·2	3·7	3·5	0·9	2·6	31·9
1849	1·5	2·3	0·6	2·5	4·4	0·2	3·3	0·4	2·8	3·1	1·2	2·4	24·7
1850	1·1	1·3	0·2	2·3	2·3	1·0	2·4	1·5	1·8	1·7	2·1	1·4	19·1
1851	2·8	1·2	4·2	2·0	0·5	1·1	4·0	2·5	0·3	1·8	0·5	0·5	21·4
Mean (4 years)	...	...	...	...	...	...	...	...	...	...	...	...	24·28

(Corresponding Mean for Royal Observatory = 24·19 in.)

[Mr. Ellis's station at Maidenstone Hill was about 930 yards S.W. of the Observatory.]

TABLE X.—Mr. J. Glaisher's Record at Dartmouth Terrace, Lewisham Hill, from 1851-1859. (Extracted from the *Registrar General's Quarterly Reports.*)

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1851	2·8	1·1	4·2	2·1	1·0	1·3	3·8	2·4	0·3	2·2	0·6	0·6	22·4
1852	...	...	...	...	...	...	...	...	...	4·1	6·3	1·6	...
1853	2·3	1·0	1·4	3·4	1·8	2·7	5·9	2·3	2·4	4·3	1·6	0·6	29·7
1854	1·7	1·1	0·4	0·7	3·6	1·2	2·1	2·3	0·8	2·6	1·6	1·4	19·5
1855	1·0	1·0	1·5	0·1	1·8	0·7	6·1	0·9	1·1	5·0	1·5	1·1	21·8
1856	...	...	...	...	...	...	...	...	...	1·6	1·4	1·6	...
1857	2·4	0·2	0·8	1·3	0·6	2·6	1·3	2·8	3·7	4·3	1·4	0·4	21·8
1858	0·9	1·7	1·0	2.3	2·2	1·2	3·0	1·5	0·7	1·4	0·4	1·5	17·8
1859	0·6	0·6	1·2	...	...	...	...	...	...	...	...	...	...
Mean (6 years)	...	...	...	...	...	...	...	...	...	...	...	...	22·17

(Corresponding Mean for Royal Observatory = 22·50 in.)

[Mr. Glaisher's station at Dartmouth Terrace was about 1540 yards S.S.W. of the Observatory.]

TABLE XI.—Mr. J. Glaisher's Record at Dartmouth Place, Blackheath, 1875-1893. (Extracted from the *Registrar General's Quarterly Reports.*)

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Totals.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1875	3·11	0·95	0·70	1·54	1·44	2·15	5·10	2·08	2·76	3·98	2·99	1·24	28·04
1876	1·17	1·77	2·66	1·60	1·22	1·24	0·72	2·02	2·73	1·72	3·13	5·92	25·90
1877	4·37	1·78	2·47	3·29	1·66	0·64	2·48	3·00	1·23	1·98	3·60	1·82	28·32
1878	1·01	1·12	0·96	3·57	3·95	4·00	0·58	5·27	0·96	1·80	3·53	1·32	28·07
1879	2·47	3·95	0·70	2·64	3·37	4·16	3·62	5·12	2·88	0·84	1·00	0·64	31·39
1880	0·33	2·36	0·48	2·21	0·58	2·38	3·89	0·97	4·14	7·94	2·04	2·79	30·11
1881	2·16	2·51	1·59	0·49	1·56	2·03	2·16	4·64	2·40	2·97	2·47	2·74	27·72
1882	1·16	1·21	1·31	2·67	1·53	2·81	2·66	1·06	2·81	6·53	2·50	2·03	28·28
1883	1·75	2·64	0·78	1·73	1·70	1·47	1·91	0·54	4·61	1·54	3·12	0·76	22·55
1884	1·73	1·25	1·24	1·12	0·93	2·11	2·18	0·25	2·16	1·08	1·18	1·99	17·22
1885	1·15	2·18	1·46	2·02	2·22	1·51	0·46	1·38	3·67	3·11	2·70	1·01	22·87
1886	3·45	0·56	0·99	1·29	4·22	0·47	2·40	1·01	1·05	1·52	3·05	3·81	23·82
1887	1·14	0·68	1·09	1·50	1·84	1·25	0·88	3·00	2·56	1·07	3·98	1·49	20·48
1888	0·95	1·06	2·53	1·55	0·63	3·50	6·59	3·59	0·78	1·26	3·74	0·90	27·08
1889	0·82	2·32	1·29	1·86	3·21	2·13	2·04	1·57	1·49	3·93	0·80	1·35	22·81
1890	1·84	1·10	1·80	1·67	1·30	2·79	4·52	2·59	0·70	1·11	1·48	0·69	21·59
1891	1·59	0·07	2·19	0·76	2·67	1·16	3·24	3·62	0·83	4·45	2·00	2·52	25·10
1892	0·40	1·65	1·03	1·39	1·65	2·25	1·54	3·06	2·44	3·99	2·30	1·19	22·89
1893	1·31	2·80	0·40	0·08	0·52	0·85	3·43	1·27	1·36	[End of record.]			...
Means 1875-1892	1·70	1·62	1·40	1·83	1·98	2·11	2·61	2·49	2·23	2·82	2·53	1·90	25·24

(The sum of the twelve monthly Means is 25·22 in.)

[Mr. Glaisher's station was about ½-mile S.S.W. of the Observatory.]

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) remarked that Mr. Nash had done excellent work in bringing such an interesting paper before the Society. He was sure they would all look forward to the further inquiry on the subject, as suggested by Mr. Nash towards the end of the paper.

Mr. W. MARRIOTT exhibited on the screen lantern slides showing the position of the various gauges at the Royal Observatory, and also portraits of the Astronomers-Royal, Sir G. B. Airy and Mr. W. H. Christie, F.R.S., and of the Meteorological Superintendents, Mr. J. Glaisher, F.R.S., Mr. W. Ellis, F.R.S., and Mr. W. C. Nash. He also showed the various patterns of rain-gauges employed, and referred to the time in his own experience when the monthly measurements were made by dipping a stick into the collected rain-water and measuring off the wetted portion. The slides also included one showing the mean monthly rainfall for the 89 years 1815-1903, and another illustrating the fluctuations of the mean 10 yearly periods. This latter slide clearly proved that a 10 years' average was not of sufficient length to give reliable information.

Mr. W. ELLIS congratulated Mr. Nash on having presented to the Society a paper containing so valuable a table of rainfall for Greenwich. Rainfall was a subject to which Mr. Nash had paid much attention, and the present table was not the first that he had put forth, a former one for the years 1841 to 1879 having appeared in *British Rainfall* for the year 1879. The present table is thus an extension forwards to the year 1903, and backwards to 1815, giving now a table for the Royal Observatory for 89 years. Mr. Nash seems to fear that his table may have exceeded available limits, but if his discussion of the results had been yet further extended he, Mr. Ellis, was sure that this would have been also gladly received. The value of the table consists in the circumstance that we now have a consistent treatment of the rainfall of the earlier years, 1815 to 1840, during which period the record was not an official one, but was maintained by the assistants of the Observatory for their own information, and various points regarding position, etc., had to be carefully inquired into and considered, a work that no one, he was sure, could better have performed than Mr. Nash, because of his intimate knowledge of the history of the matter. He did not propose to speak much of details. Mr. Marriott's lantern slides had clearly brought out some features; he had, however, divided the 89 years into four periods of 22, 23, 22, and 22 years, and found the separate annual means of these groups to be 24·92 in., 24·17 in., 25·50 in., and 22·87 in. respectively. Combining the means for the first three periods, we get a general mean of 24·86 in., that for the last period is thus two inches lower, a considerable falling off for a 22-years' mean as compared with that for 67 years. Again the greatest annual fall was 35·54 in., and the least was 16·38 in., less in amount by more than one half. These were serious variations for those to consider who had to deal with questions of water supply. The curious fall in the mean monthly values from July to September he had found to be in close correspondence with what was observed at Camden Square. He was sure that the Society would be glad to have this table in the *Quarterly Journal*, and he hoped that Mr. Nash would in due time carry out his idea of dealing with the much more difficult question of daily rainfall.

Mr. F. J. BRODIE considered that the Society was greatly indebted to Mr. Nash for the valuable information given in the paper. Last year, when the subject of rainfall attracted the notice even of "the man in the street," numerous inquiries were made as to how matters stood in comparison with earlier years. Towards the close of the year the Meteorological Office record for London,

extending back to 1866, was easily beaten, and recourse was naturally had to the longer series of observations made at Greenwich. In such circumstances it was rather disconcerting to find that while a published record existed for as long back as the year 1815, some of the earlier values were so doubtful that they could not be quoted with any degree of confidence. Mr. Nash had now furnished a more reliable set of figures, and under the sanction of such an authority, the new values might doubtless be accepted as very nearly, if not absolutely, correct. Some doubt appeared to attach to the values for the years 1867 and 1868, and at the end of the long table the author had supplied figures which he considered more reliable. These values might perhaps with advantage have been inserted in the table in the place of the less authentic ones. The question as to the length of period required to yield an absolutely reliable average was still to some extent an open one. In the very valuable paper on rainfall recently presented to the Institution of Civil Engineers, Dr. Mill had suggested the 30-year period, 1870-99, as yielding a satisfactory mean, and had given excellent reasons for holding such a view. The subject was, however, an extremely difficult one, and would in all probability continue to exercise the minds of meteorologists for a long time to come. The expression, a "rainy day," as applied to all cases in which the fall reached so trifling an amount even as 0·01 in., seemed objectionable. In some of the recent publications of the Meteorological Office the term "rain day" had been substituted. He (Mr. Brodie) was inclined to favour the use of the expression, "a day with rain."

Mr. C. HARDING said that he had for many years used the Greenwich records for comparison with the London readings, both for pressure and temperature as well as rainfall. They were good observations and carefully taken. In his own manuscript copy he had been in the habit of putting a + or − sign against the rainfall, so that he could see at a glance which months were above or below the average. The only year that was above the average for the past 10 years was 1903, and going back as far as 20 years there were only three others. The December values were, however, as a rule, in excess, the other months showing the deficit. He would suggest that some difference in the type might be made in printing the tables, so that any one searching for facts might readily see which months were above or below the average.

Dr. H. R. MILL said he would like to express his high appreciation of the value of the work done by Mr. Nash. It was a good thing to get observations taken, but even better to rescue a long series of records from unjust suspicion. The whole Greenwich record could henceforward be looked upon with a degree of confidence not possible before. He would have liked to see clearly set out the corrections that had been applied to the original figures, and the reasons for their use, as some differences of opinion had arisen on the matter. He had worked out the ratio of the three driest years to that of the whole period, and the figures came out at 85 per cent. The usual proportion of the average of long records had been found to be 80 per cent, and this excess of 5 per cent was a comparatively large difference. He hoped that Mr. Nash would go on to discuss the daily rainfall. He was pleased to hear the various opinions expressed as to the term "rainy days." He himself would like to drop the "y" in the word rainy. It was necessary to have a concise term, but, speaking generally, he did not think any one was now misled by the phrase.

Dr. H. N. DICKSON remarked that every other speaker had an official connection with Meteorology, but as a "country cousin" he would like to express his satisfaction in possessing in so complete a form the information prepared by Mr. Nash. It was exceedingly difficult for private individuals to attempt the preparation of papers like the present, owing to the difficulty of access to the observations, although they were always conscious of the courtesy of the officials

in assisting those whose work kept them at a distance. He was very pleased to see this authoritative statement of the Greenwich rainfall, and was keenly sensible of its value. It was interesting to note the distribution of the monthly rainfall during the dry years, and it was noticeable that the drought of the last ten years was mainly that of the summer months. The rainfall in the winter was more nearly up to the normal amount. With regard to Mr. Harding's suggestion of typographical differences in the tables, he thought it would be best to leave them as they were. He himself had suffered a great deal, especially with regard to maps, in working with figures that had been thus treated, and had found the plan a very disturbing element. This was especially so when the precise average was not definitely known.

Mr. W. C. NASH, in reply, said that he wished to express his thanks for the kind way in which the paper had been received. He did not like to include the amended figures for the years 1867-68 in Table I., as he was not quite sure whether they were perfectly reliable. Respecting the "rainy days," the term itself was somewhat misleading, but in the present paper he had included amounts of ·005 in. and upwards as representing a "rainy day," in accordance with the rule adopted by Mr. Symons. There were, however, not very many days of such small rainfall as ·005 in. To indicate the difference from the average in the tables typographically would be rather a difficult matter, as two different types had already been employed in the paper. Mr. H. Sowerby Wallis, in his paper on the Camden Square rainfall, 1858-1902 (*British Rainfall*, 1902), had already made a comparison between the Greenwich and Camden Square averages, and in relation to this he would like to draw attention to a comparison he had made between the monthly averages for the 89 years, 1815-1903, for Greenwich, and those for the 33 years, 1871-1903, for Greenwich and Brixton.

MONTHS.	89 years, 1815-1903.	33 years, 1871-1903.	
	Greenwich.	Greenwich.	Brixton.
	in.	in.	in.
January . .	1·80	1·73	1·82
February . .	1·52	1·53	1·59
March . . .	1·52	1·47	1·49
April . . .	1·61	1·62	1·66
May . . .	1·95	1·75	1·71
June . . .	1·97	2·12	2·18
July . . .	2·45	2·47	2·45
August . . .	2·33	2·34	2·38
September . .	2·25	2·08	2·12
October . .	2·72	2·73	2·80
November . .	2·29	2·25	2·34
December . .	1·95	1·97	2·02
Year . .	24·36	24·06	24·56

In conclusion, the agreement between the average number of rainy days for the London district, as based upon different series of determinations, was dwelt upon, and the following table was adduced (see next page):—

Months.	Average Number of Rainy Days.		
	Greenwich. 63 years, 1841-1903.	London. 56 years, 1807-1862.[1]	Camden Square. 45 years, 1858-1902.[2]
January	14·8	13·4	15·3
February	12·4	12·4	13·2
March	13·2	11·9	13·4
April	12·0	12·8	12·3
May	12·4	12·7	12·4
June	11·6	12·0	11·7
July	12·6	13·0	12·2
August	12·9	12·9	13·2
September	12·3	12·7	12·5
October	15·1	14·4	15·0
November	14·0	13·6	14·0
December	14·2	13·6	15·3
Year	157·5	155·4	160·5

[1] Vernon, *Memoirs Lit. and Phil. Society of Manchester*, 1861-62. Vol. 2. Third Series, p. 335.
[2] Wallis, *British Rainfall*, 1902, p. 34.

Frost Effects at Niagara.—Mr. Orrin E. Dunlop, writing from Niagara Falls, sends us some striking photographs of ice formations noticed at Niagara during the past winter. An ice bridge formed in the gorge below the Falls in December last, and thousands of persons crossed from shore to shore on this curious formation. Another remarkable object was an ice mountain composed of a massive collection of frozen spray. Usually this mound rests on the débris slope between the inclined railway building and the falling water, but last winter it bridged the torrent of the American Fall and extended over in front of the Fall. Here a grotto-like effect was caused by the wearing tendencies of the falling water, and the effect was repeated on the outside or ice bridge side, of the mountain. From the ice bridge the different layers of ice that went to make up the mound could be distinguished. A part of the cliff over which the American Fall usually flows was hidden under hugh icicles that hung from the brink to the talus at the foot of the precipice.

In Prospect Park the ice that gathered on the trees was very destructive. The ice grew so heavy that the largest trees lost many branches, and some were left with only their trunks. The grandest sight of all was, says Mr. Dunlop, at Prospect Point in the middle of February. The wind blew from the South-west, and the spray of the American Fall fell upon the Point, where it was frozen with great rapidity. Every hour added to the mass, until finally it was more than 30 feet high from the water as it plunged over the American Fall. The mound extended back into the park, half-burying trees that were already weighted with great loads of ice. Realising that the mound might damage the lower section of the inclined railway building or cause loss of life among the many who climbed about the ice and mountain below, it was resolved to try to blast it away. To accomplish this, holes were drilled along the upper river side, and eight sticks of dynamite placed in them; but their explosion accomplished little, owing to the slight resistance offered by the ice.—*Nature*, March, 24, 1904.

EFFECTS OF A LIGHTNING STROKE AT EARL'S FEE, BOWERS GIFFORD, ESSEX, APRIL 13, 1904.

By Rev. C. F. BOX.

[Read June 15, 1904.]

Quite early, about 1 a.m. on the morning of Wednesday, April 13, rumblings of thunder across the river, on the Kentish side, and with occasional lightning flashes, more or less vivid, indicated the approach of a thunderstorm.

My experience is that when a thunderstorm crosses the river it is usually very severe in the immediate neighbourhood skirting this Essex shore.

The above proved to be no exception, for, after a desultory continuation of thunder and lightning accompanied by rain until about 3 a.m., when the rain ceased, there fell a dead calm, "a stillness which might be felt," and then, at about five minutes afterwards, came a blinding flash, lighting up the whole neighbourhood for miles around, followed immediately by a crashing explosion, and shaking this vicarage to its foundations. After this shock the rain fell in torrents, and continued to do so more or less until daybreak.

Upon inquiry during the day, I learnt that it was at Earl's Fee, Bowers Gifford, a farm owned by Mr. James Heygate, about two miles distant from this village, and situate upon rising ground overlooking Canvey Island and the Thames, that this lightning shock had seemingly spent its force.

The farmhouse is inhabited by John Parish, the bailiff, and his family, and he tells me that they were all almost stunned by the effects of the explosion. "The whole place appeared to be on fire." The horses broke from their enclosure, a calf in its stall was paralysed and died the next day, and a lamb in the adjoining field was killed.

John Parish then discovered in the early morning that in an oat-field, and about a hundred yards distant from the house, "the earth was torn up and scattered about," and upon visiting the spot he found what I will now carefully and accurately describe as the result of my own observations, for I have thrice visited the spot.

Before, however, doing so, I may mention that the shock of this explosion was severely felt by the people of this village, and that two residents upon a part of the parish known as "the Estate" saw from their respective windows, about a mile and a half distant from the spot affected, what appeared to be, one said, a cylinder, and the other, a ball of fire, descend and then explode, "casting darts" in all directions.

The oat-field had recently been dredged and was as smooth as a table, and the area affected included almost six furrows. It will be seen that there are three distinct sets of holes ranging from 9 inches to about 1 inch in diameter. The furrows of the oat-field run directly north and south, and the surface presents the appearance in Fig. 1, where the measurements and positions are shown.

These holes are perfectly circular, and, diminishing in size as they go downwards, remain so on to the perfectly rounded ends at the bottom.

The ground was allowed to remain undisturbed for a time until the owner should come across from Southend to view them.

However, I prevailed upon J. Parish to dig sectionally, with the result shown in Fig. 2. The soil is stiff yellow clay, and it will be seen that a section may be said to represent a section of Gruyère cheese.

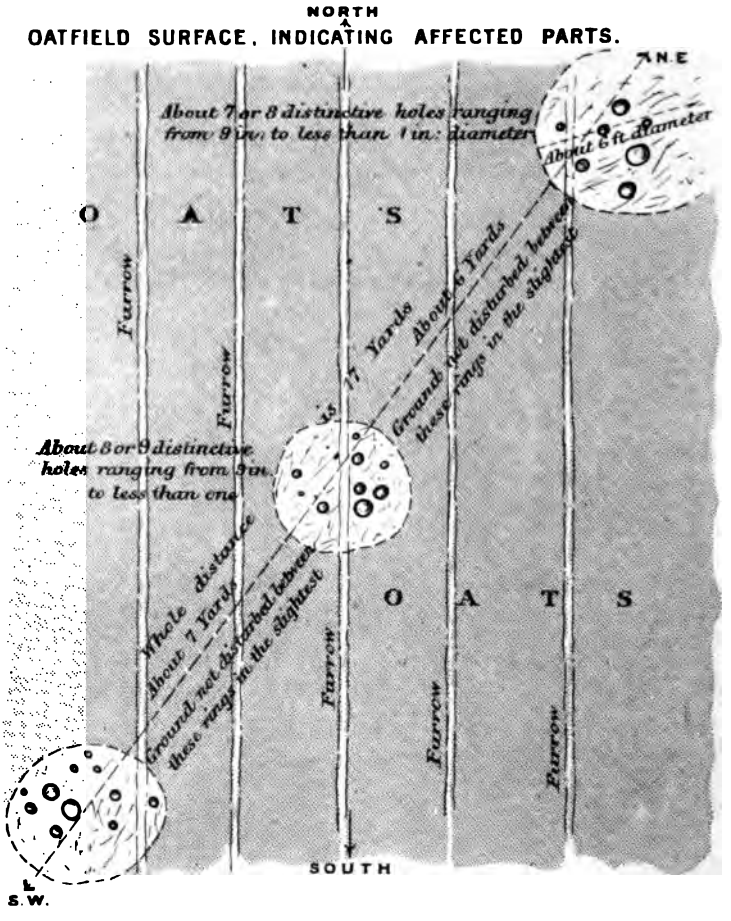


FIG. 1.

As the man observed, "the holes are as clean cut as though bored with an auger."

It will be noticed that the earth was disturbed and depressed at the surface immediately about the holes to the extent of almost a foot at the surfaces of some of the larger ones, and a few inches generally. I discovered one large clod of earth blown to the distance of almost 17 yards, and others were scattered about.

Upon digging, it was found that the larger holes, and more especially the 9-inch shown in Fig. 2, branched off into several directions like, as

J. Parish said, "an outspread hand," and the ends certainly represented finger-ends.

When J. Parish first visited the spot he found the surface, about the holes, like "a light pudding." But the holes were perfectly dry, and the surface soil was dried by the sun, and not by drainage through the holes, as the clay is well-nigh impervious.

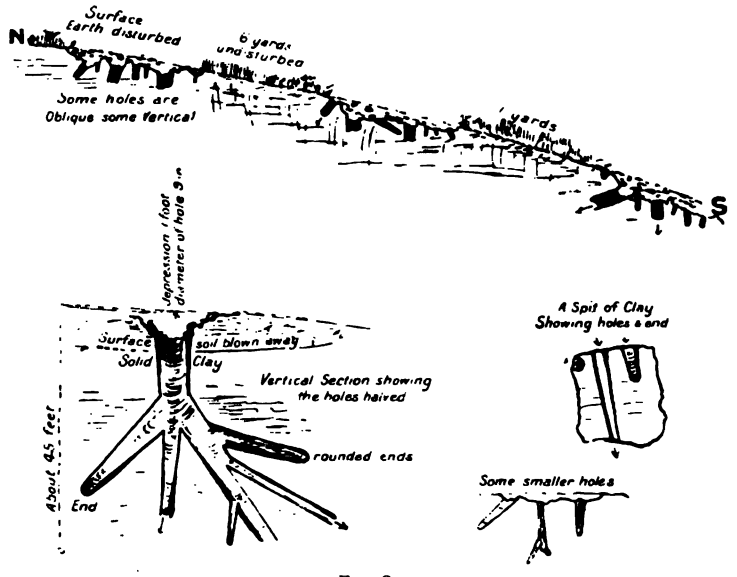


FIG. 2.

I employed J. Parish to dig to the depth of several feet. In doing this we arrived at the ends of many of the holes; but it seemed unnecessary to do so in the case of the rest, as we were satisfied that we should find nothing of a material nature there, and they appeared to descend to a great depth.

DISCUSSION.

Mr. W. MARRIOTT said that perhaps some account of the thunderstorm which passed over Earl's Fee might be of interest to the Fellows. It appeared from the records received by the Society that a thunderstorm passed over the south-eastern and eastern districts on the early morning of April 13. The storm burst over the south coast at 2 A.M. and reached Lowestoft by 5 A.M., the rate of travel being approximately 50 miles per hour. From an examination of the Daily Weather Maps it seemed that the series of storms was somewhat similar to those of May 18-19, 1888, and June 2, 1889, which he (Mr. Marriott) had described in the "Report on the Thunderstorms of 1888 and 1889," *Quarterly Journal*, vol. 18, p. 23, and which he had designated as "line" thunderstorms. The storms on those occasions were tracked across England in a direct line from south to north for over 400 miles, the rate of progression being about 50 miles an hour. The thunderstorms also occurred during the night and early morning, and they were succeeded in the afternoon by slow

moving thunderstorms. It was remarkable that on April 13, 1904, there were also thunderstorms in the afternoon in the south-western part of the country.

He (Mr. Marriott) was much interested in Mr. Box's account of the effects of the lightning stroke at Earl's Fee, and with a view to offering a possible explanation of the phenomenon he showed a number of lantern slides of various types of lightning flashes. He also said that with moving cameras it was often found that there were several flashes on the plate following precisely similar courses; and he mentioned especially those obtained by Mr. Ninnies at Balham, and by Dr. Hoffert at Ealing, which were referred to in his paper, "The Thunderstorms of June 2, 6, and 7, 1889," *Quarterly Journal*, vol. 15, p. 223. These showed that the flickering or repeating character of the lightning was really due to a succession of flashes following the same path. It would be interesting if, as suggested recently by Dr. Shaw, stereoscopic views of lightning could be obtained, as by that means it might be possible to obtain further information on this point. Mr. Box had stated that the series of holes were about 6 or 7 yards apart. He (Mr. Marriott) suggested that these might have been caused by repeating lightning, which although appearing to an ordinary observer as a single flash, might in reality be three flashes 6 or 7 yards apart. The soil had been stated to be clay; if, however, it had been of a sandy nature, there is no doubt that the sand would have been fused and "fulgurites" formed. Specimens of fulgurites were to be seen at the British Museum, and drawings of some were shown at the Society's Exhibition of March 1888 by the late Mr. G. J. Symons, F.R.S., *Quarterly Journal*, vol. 14, p. 234. Mr. Box was to be commended for the careful manner in which he had investigated the matter, and for bringing it before the Society.

Mr. W. Greatheed said he knew the neighbourhood westward of that described by his friend Mr. Box, and had wondered whether it was especially addicted to thunderstorms. On looking at the map, it would be seen that the river must exert considerable influence on the weather over the surrounding country. Wind will always hug a channel, that is to say, the banks of a river deflect the true course of the wind. Moreover, the influences which effect the tide of a river, in his opinion, also produced atmospheric tides, and air-movement was often to be found in a tidal valley when there was none elsewhere. The hills, too, on either shore of the river were factors in slanting the wind. All these points considered might prove to be local determinants, if this particular district was more often than others visited by storms. Thunderstorms were nowhere infrequent, but he would like to ask how many strokes of lightning are impressed on the average man's mind. In his own memory only three stood out with any clearness. These occurred on or just off the old plateau-gravel bank of the river Thames, at 50 feet above sea-level and, linearly, all within one mile of each other. The gravel is water-bearing; in two of the cases trees were struck, and in one a house. The bank faces south-east, and is northerly of the Lower Hope Reach.

Mr. R. Inwards remarked that it would have been interesting to know if steam was observed issuing from the holes, or if the mud found near the openings was of very high temperature. No doubt Mr. Marriott was correct in supposing that if the soil had been sandy, fulgurites would have been formed. It would have been interesting if a plaster cast had been taken of the principal hole so as to put its remarkable branchings on permanent record. Failing this, a photograph might still be possible.

Mr. A. Hands said that this was a type of case not often investigated, as attention was more frequently paid to buildings damaged by lightning. He had in keeping a map on which he marked all instances of damage by lightning, and the county of Essex, especially the south-eastern portion, was more thickly

marked than any other part of the country, except perhaps Yorkshire. He did not quite agree as to the suggestion of the multiple flash striking the three holes successively. The first flash would cause a vacuum, and the others would follow in the same line. He did not think subsequent flashes would be strong enough to strike out a new path. He was of opinion that the present instance was a case of a bifurcated discharge, and in such instances sometimes a dozen branches would leave the main trunk and strike the earth. The ground, however, must have been very dry at the time. The ground, too, was cut up on the surface, which was also generally the sign of dry conditions. With regard to the question of balls of fire and ball lightning, he had followed up all such supposed cases for the past ten to twelve years, but had always found the description of such occurrences differed and disagreed with what was to be expected if globular lightning was really existent. Most instances of so-called ball lightning were brush or glow discharges, and in one case it proved on investigation to be water.

Mr. R. G. K. LEMPFERT, on behalf of Dr. Shaw, exhibited some records of the Dines micro-barograph taken in London, and among others that taken at Oxshott on April 13, on which the record of the thunderstorm was well shown. The instrument is designed to magnify the small and rapid changes of atmospheric pressure, while the larger and slower variations are lost. There was one point on which he would like to ask for further information, and that was whether Mr. Box could say if the holes had ever been filled with water. Mr. J. Parish stated that the ground was like a "light pudding" but the holes perfectly dry, but there had been heavy rain both before and after the flash of lightning. If the holes had been filled with water, their round, smooth character might perhaps be due to its action. Evaporation under such circumstances would be a very slow process, and the water could only have escaped by percolating through the clay. In this case we should expect to find some sediment in them.

THE PRESIDENT (Capt. D. WILSON-BARKER) said that the discussion had raised some curious and interesting points. A plaster cast of the holes would certainly have been of much value, if the material had been at hand for the making of such a cast. With regard to triple lightning, he had seen streams of flashes coming from a cloud heavily charged with electricity and discharging beneath. He had recently seen a house that had been struck by lightning; the flash had cut a clean hole through the tiles of the roof, and passing to the ground, had gone out at the open door. He had often heard of ball lightning, but had never seen it, nor any one who could accurately describe having seen such a thing.

The Rev. C. F. BOX, in reply, said that it had given him great pleasure to communicate the occurrence to the Society, and he was much obliged for the privilege of being able, in consequence, to hear the after discussion upon the subject. In answer to the theory set forth by one gentleman who doubted the existence of either ball or globular lightning, he said that he could give no further information upon the matter beyond quoting the two distinct witnesses who were certain (independently of each other) that they saw lightning descend in cylinder and globular form respectively and explode. Personally, he should very much like to know what could have caused the terrific explosion. It was reported that "a thunderbolt had burst and scattered fragments in all directions, thus causing the holes in the ground." This would be the most natural inference of the uninitiated.

"Southern Cross" Antarctic Expedition.—We have received from the Royal Society the Magnetical and Meteorological Results of the *Southern Cross* Antarctic Expedition, 1898-1900.

This volume contains the results of the magnetic and meteorological observations taken during the years 1899-1900.

A station was organised at Cape Adare, long. 170° 9′ 30″ E., lat. 71° 18′ S., on February 17, 1899, by the scientific members of the expedition, and observations were made at this place until January 28, 1900.

The meteorological observations at Cape Adare, which cover a period of 11 months, have been prepared for publication by the staff of the Meteorological Office, while the magnetic records have been discussed by Dr. C. Chree. A summary of observations contained in the meteorological log of the *Southern Cross*, December 1898 to March 1900, and notes on the Aurora Polaris, and on the relation between winds and temperature observed at Cape Adare during 1899, are also included in the volume.

The following table gives some of the results of the observations at Cape Adare from March 3, 1899, to January 28, 1900 :—

RESULTS OF OBSERVATIONS AT CAPE ADARE, MARCH 3, 1899, TO JANUARY 28, 1900.

1899-1900.	Mean Pressure at 32°, 19 ft. above sea-level.	Air Temperature. Means of		Absolute Min. and Max.			
		Min.	Max.	Min.	Day.	Max.	Day.
	ins.	°	°	°		°	
March (28 days)	29·056	13·8	22·0	−2·8	26	31·1	5, 6
April	29·266	5·2	15·6	−10·3	20	31·5	3
May	28·995	−10·6	2·6	−31·5	14	23·0	5
June	28·937	−19·3	−4·8	−36·4	4	13·9	12
July	29·378	−17·6	−1·0	−39·4	10	23·6	15
August	28·993	−22·7	−4·3	−43·5	5, 6	18·7	16
September	28·611	−18·8	−3·9	−31·9	13	11·3	7
October	28·859	−10·7	4·6	−36·5	1	19·4	16
November	29·323	9·0	24·1	−4·3	2	45·5	29
December	29·231	27·5	35·6	20·5	12	42·0	26
January (28 days)	29·180	29·7	37·0	25·2	9	48·7	24
Whole Period	29·075	−1·3	11·6	−43·5	Aug. 5,6	48·7	Jan. 24

Months.	Rainfall.					Wind.—No. of Observations of								
	Total.	Max.	Day.	Days of Rain.	Days of Snow.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
	ins.	ins.												
Mar.	·072	·070	25	1	4	0	8	10	8	8	2	2	6	12
Apr.	·250	·190	6	2	5	8	4	5	9	7	1	2	1	22
May	·205	·205	8	1	8	5	2	3	10	13	1	0	0	28
June	...	...	...	...	5	1	0	5	10	12	6	0	0	26
July	...	...	...	...	11	0	1	7	15	7	0	1	2	28
Aug.	...	...	...	...	6	1	2	2	11	12	1	1	1	30
Sept.	...	...	...	...	9	1	1	4	18	11	1	1	0	23
Oct.	...	...	...	...	2	2	0	7	11	7	3	1	0	31
Nov.	...	...	...	...	4	1	0	2	12	8	2	1	1	33
Dec.	...	...	...	...	5	3	0	10	11	4	4	2	1	27
Jan.	·910	?	?	7	7	2	1	11	15	4	1	1	2	19
Total	1·437	...	...	11	66	24	19	66	130	93	22	12	14	279

AN INSTRUMENT FOR DETERMINING THE TRUE DIRECTION AND VELOCITY OF THE WIND AT SEA.

By A. LAWRENCE ROTCH, F.R.Met.Soc.,
Director of Blue Hill Observatory, U.S.A.

[Read June 15, 1904.]

The problem of determining the true direction and velocity of the wind on a moving vessel is an old one. As long ago as 1848, Prof. C. P. Smyth arranged jointed scales on movable graduated circles for reducing the apparent wind to the true wind,[1] and later graphical or trigonometrical solutions with calculated tables were given by Miller,[2] Rykatcheff,[3] Mohn,[4] Waldo,[5] and the United States Hydrographic Office.[6] All these required that there should be known the speed of the ship, the angle that the apparent wind makes with it, and the force or velocity of this wind. The latter must usually be estimated, since, even if an anemometer is available on board ship, there are few positions where it will give accurately the relative velocity of the wind, on account of the upward deflection occasioned by striking the vessel. Some experiments made several years ago by the writer with a Dines portable pressure-anemometer demonstrated that in but few localities on board a vessel steaming through calm air was its speed indicated by the horizontal movement of the air recorded by the anemometer. One such place was just aft of the bow, but elsewhere a less speed was usually indicated, although under the bridge the compressed vein of air flowed astern faster than the boat moved ahead.

In view of the difficulty of measuring the apparent velocity of the wind on a moving vessel, any method of ascertaining its true velocity with considerable accuracy is desirable, from a scientific as well as from a practical standpoint, and the following graphical solution was published by the writer in *Science*, vol. 15, pages 72 and 73. In Fig. 1 let AB be the wind due to the motion of the steamer in the opposite direction, and AC the direction of the wind relative to the vessel as shown by the drift of its smoke, giving the angle BAC. Then, by measuring the angle, DBA, that the true wind makes with the vessel, which is easily done by watching the wave crests as they approach it, we obtain the third side, BC, of the triangle. This represents in direction, and also in length, on the scale used in setting off the speed of the ship, the true direction of the wind relative to the vessel, and also its true velocity. The method fails when the wind direction coincides with the ship's course and becomes inaccurate when the angle between them is small; but in other cases, since the course and speed of the ship are always accurately known, and the two angles, BAC and DBA, can be measured with considerable precision, the results obtained are very satisfactory.

To avoid the inconvenience of plotting these data, the writer devised

[1] *Trans. Roy. Soc. Edin.*, vol. 16, No. xxxi.
[2] *True Direction and Velocity of Wind observed from Ships while Sailing*, London, 1870.
[3] *Repertorium für Meteorologie*, vol. 7, No. ii.
[4] *Meteorology of Norwegian North Atlantic Expedition*, 1883.
[5] *Monthly Weather Review*, Jan. 1887.
[6] *Pilot Chart of North Atlantic*, Nov. 1901.

last year the instrument illustrated in the accompanying photograph, which was constructed by Mr. L. Casella of London, and exhibited during the Southport meeting of the British Association. The apparatus has two brass discs, 3 ins. in diameter, marked with the cardinal points of the compass, each quadrant being divided into 90°, beginning at North and proceeding in a right- and left-handed direction to East and West respectively, and again starting at South and progressing in the same

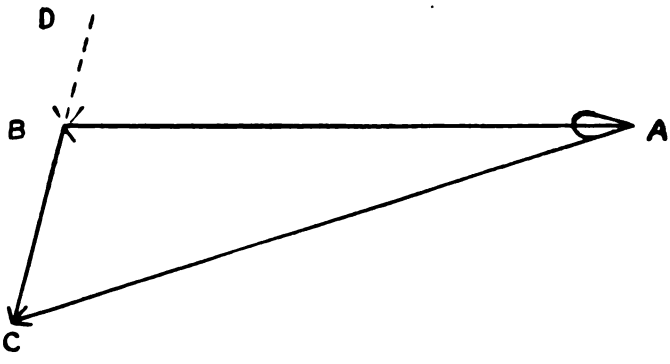


FIG. 1.

directions to West and East respectively. One of these discs is pivoted near the end of a boxwood rule, 10 ins. long, having 30 divisions, and bearing the legend "Ship Moving," with an arrow pointing away from the pivot. On this pivot there is also mounted, near one end, a similar rule about 17 ins. long, containing 60 of the above divisions, and marked "True Wind," with an arrow directed away from the pivot. A brass slide upon the short rule carries the other movable disc and also another

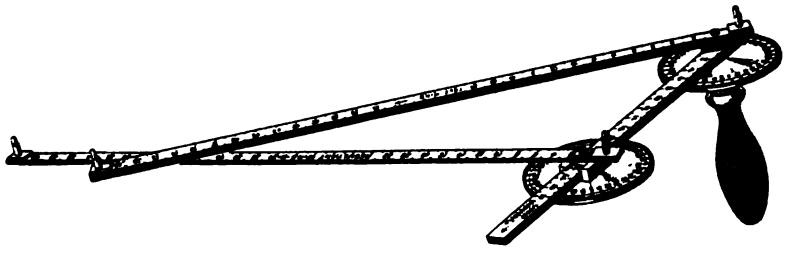


FIG. 2.

pivoted boxwood rule, likewise divided into 60 parts and marked "Resultant Wind," with an arrow headed away from its pivot. Sights are attached to both ends of the long rules, and a handle screws into the back of the disc that does not slide. The instrument folds together so as to pack away into a small box.

It is used as follows:—After rotating both discs until the divisions on their circumferences indicate at the middle of the "Ship" rule the true course of the vessel, the slide is placed on the figures representing its actual speed in miles per hour. Then, sighting along the "Ship" rule fore and aft in the direction indicated by the arrow, and holding the

instrument steady, the "True Wind" rule is turned until its sights are normal to the line of advancing wave crests. In practice this is most easily done by standing amidships and holding the "Ship" rule against the windward rail, then, sighting as described, the short end of the "True Wind" rule will indicate on its graduated disc the direction from which this wind comes. The reading is noted, or the rule is clamped fast, and the observer stands to leeward of the funnel. It being certain that the "Ship" rule is again exactly fore and aft, and the "True Wind" rule in its former position, the "Resultant Wind" rule is turned until its sights coincide with the direction taken by the receding line of smoke, or with the mast-head pennant, should there be no smoke. The short end of this rule then indicates on its disc the real direction from which the resultant wind comes, and at the intersection of the two long rules there may be read off on their respective scales the velocities of the true wind, and of the wind experienced on board.

The instrument was practically tested last autumn, during a transatlantic voyage on a North German Lloyd steamer. Observations were made with the instrument each morning between 8 and 9 o'clock, and the corresponding entries in the ship's log for 8 a.m. were obtained at the end of the voyage. The course of the ship and its speed were known each day. The subjoined table shows a close agreement between the two sets of observations, and, assuming that the estimations of wind direction and force made by the ship's officers are approximately correct, it appears that any landsman may obtain the same or better results by employing this simple instrument.

It should be said that, although evolved quite independently, this apparatus closely resembles the device proposed by Prof. C. P. Smyth. It differs, however, in its application, since, while Prof. Smyth was obliged to employ the objectionable anemometer, and, after ascertaining, in some way, the direction of the apparent wind, had still to transfer its velocity and direction to his scales and circles. With the instrument just described the angles of the apparent and true wind relative to the ship are measured

COMPARISON OF ESTIMATED AND MEASURED WIND AT SEA.

8 a.m. Sept. 1903.	Ship's		Estimated Wind.		Measured Wind.	
	Course towards (True)	Speed in Statute Miles per Hour.	Direction from and Force (Beaufort).	Equivalents in Degrees and Miles per Hour.[1]	Direction from and Velocity in Miles per Hour.	Resultant Direction and Velocity.
22	N. 81° W.	17·5	SSE. 7	S. 22° E. 31	S. 45° E. 32	S. 12° E. 22
23	N. 89° W.	17·0	SW. 8	S. 45° W. 37	S. 40° W. 40	S. 50° W. 51
24	N. 90° W.	14·2	W. 7	W. 31	(W. 30)	(W. 44)[2]
25	S. 76° W.	14·7	NNW. 8	N. 22° W. 37	N. 30° W. 40	N. 55° W. 46
26	S. 71° W.	15·6	W. 2	W. 7	N. 70° W. 10	N. 90° W. 24
27	S. 76° W.	17·4	WNW. 4	N. 68° W. 14	N. 70° W. 16	N. 85° W. 32
28	S. 73° W.	17·4	S. 4	S. 14	S. 10° E. 16	S. 30° W. 24
29	S. 73° W.	17·4	NW. 4	N. 45° W. 14	N. 35° W. 14	N. 75° W. 26

[1] The conversion of forces on the Beaufort Scale to velocities in miles per hour was made by Mr. Curtis's table, *Quart. Jour. Roy. Met. Soc.*, vol. 23, p. 41.

[2] The velocity of this wind could not be measured without an anemometer, because the true direction and the resultant direction were the same.

directly, and, by utilising the ship's course and speed as a base, absolute directions and velocities of both winds are immediately ascertained. In conclusion it may be pointed out that the velocity of the resultant wind is of importance in flying kites at sea, a work which was first undertaken by the writer in 1901 (see this *Journal*, vol. 28, p. 1), and which recent experiments and propositions indicate is likely to become an important method of meteorological investigation.

DISCUSSION.

THE PRESIDENT (Capt. D. WILSON-BARKER) remarked that they were all indebted to Mr. Rotch for his interesting paper. He had seen the instrument at Southport last year, and it appeared to him very useful. He did not, however, think that for practical purposes it would supersede the methods and tables at present in use. In many cases the ship's officers were not able to reduce the observations at once, but only to take the readings and to note and correct them afterwards.

Origin of Auroræ.—In a lengthy communication to the Société Francaise de Physique (*Bulletin*, No. 3, 1903), M. C. H. Nordmann discusses the causes which produce auroræ. After reviewing the various observations of the phenomena attending auroræ, and discussing in detail the theories of Arrhenius and Birkeland, he formulates his own theory in the following words :—"I think that the Auroræ Boreales are luminous phenomena produced in the upper atmosphere by the Hertzian waves emanating from the Sun." In support of this belief he discusses each of the phenomena attending the appearance of auroræ, and shows that the forms and orientation, the extension, the frequency, the height, the spectrum, and the diurnal, annual, and undecennial periodicities may all be explained by the application of his theory. In discussing the relations between auroræ, solar disturbances, and magnetic storms, he states that the emission of the Hertzian waves becomes more intense in the regions of spots and faculæ at the period of maximum solar activity, and quotes the observed fact that it is only the rapidly moving auroræ (*i.e.* those due to the greater disturbances) which apparently affect the magnetic needles.—*Nature*, March 24, 1904.

THE INTERNATIONAL OBSERVATIONS OF CLOUDS.

By Dr. H. HILDEBRAND HILDEBRANDSSON, Hon.Mem.R.Met.Soc.

A Report to the Permanent International Meteorological Committee.

[Translated by R. G. K. Lempfert, M.A., of the Meteorological Office.]

Historical.

In a letter to the Permanent International Meteorological Committee, dated May 25, 1878, a number of points connected with the observation of clouds were discussed, and the following proposal was made :—

"To sum up, we confine our demands to asking that the direction of motion of clouds be observed at several stations in each country, and that the results be published. For present purposes it is desirable to draw a distinction between upper and lower clouds only, as is already done here and in the publications of the Signal Office of Washington. When the observer is in doubt as to the classification of a particular cloud, he should include it among the lower clouds."

At the meeting held in Utrecht the Committee resolved to bring the question before the Conference to be held in Rome in 1879.[1]

The said Conference adopted the following resolution : "That the observation of the direction of the upper clouds at several stations in each country, and the publication of the results, are strongly recommended."[2]

In accordance with this resolution, the permanent Committee took steps to organise a service for this purpose. I was invited to attend the meeting held in Copenhagen in 1882, and I there gave the Committee an account of the methods I proposed to adopt in these researches. The Committee agreed to request Messrs. de Brito Capello, Hildebrandsson, and Ley to prepare a report on the question of the observations of cirrus.[3]

At the next meeting of the Committee, held in Paris in 1885, I presented the report of the sub-committee appointed at Copenhagen.[4]

Thereupon the following resolution was adopted: "The Committee recommend the observation of the movement of clouds, especially of cirrus, in accordance with the scheme drawn up by the sub-committee, and the introduction at least for some stations of these data into the meteorological telegraphic reports."[5]

This scheme contemplated a division of clouds into two groups only :—

A. Upper or cirriform clouds.

B. Lower clouds.

In cases where the observer was in doubt as to the classification of a cloud, he was to include it among the lower clouds.

The following particulars were to be entered in the registers :—

(1) The hour of observation.

(2) The direction of motion of the upper clouds.

(3) The velocity of motion of the upper clouds. The velocity, estimated by eye, was to be indicated on the following scale :—0 = motionless ; 1 = very slight motion ; 2 = ordinary motion ; 3 = rapid motion ; 4 = very rapid motion.

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[1] Minute of October 17, 1878.

[2] Minute of April 21, 1879.

[3] Minute of August 4, 1882.

[4] Minute of September 1, 1885. See also Appendix III. to the Report of Paris Meeting, 1885.

[5] Minute of September 3, 1885.

If a reflecting nephoscope, such as that by Fineman, was used, the observer was recommended to draw a circle round the centre such that its radius corresponded to an angular movement through 15°, or better still, to draw two concentric circles such that the image of a cloud near the zenith took the same time to pass from one circle to the other as the cloud takes to travel 15° away from the zenith.

(4) The radiation point.

(5) The density (0 to 4) and position of the bank of cirrus.

(6) The direction and velocity (0 to 4) of the lower clouds.

(7) The direction and velocity of the wind as ordinarily determined.

The publication of the observations described above was to be carried out *in extenso* in each country.

During the following years observations were made on this plan in several countries.

These observations led to unsatisfactory results. It soon became evident that the division of clouds into only two classes, upper and lower clouds, was insufficient. Not only cirriform clouds, *i.e.* true cirrus and cirro-stratus, but also cirro-cumuli, which float at a much lower level, were regarded as upper clouds, while all other forms, from alto-cumulus of which the height is often over 16,000 feet (5000 metres), to stratus which at times lies almost on the earth's surface, were regarded as lower clouds. In view of the importance of the subject, and of the evident necessity for determining the motion and height of each cloud form separately, the advantage of an international classification of clouds was obvious.

As early as 1873 the Meteorological Conference assembled in Vienna had requested the various meteorological organisations and observatories to publish accurate diagrams of the forms of clouds regarded as typical in each country.[1] To meet this request I published in 1879 a paper entitled, *Sur la classification des nuages employée à l'observatoire météorologique d'Upsala*,[2] together with a number of photographs prepared under my supervision by M. H. Osti. Unfortunately this example was not followed elsewhere.

In 1884 and 1885 Messrs. Ekholm and Hagström carried out some measurements of the true height and velocity of the different forms of clouds at Upsala by means of theodolites placed at two stations a convenient distance apart and connected with each other by telephone.[3] These fundamental researches yielded some new and unexpected results, and it became of great importance to ascertain whether these would hold good in other localities differing from Upsala in topography and climate. To contribute towards the solution of this problem, Messrs. Hagström and Falk, with the assistance of a grant received from the University of Upsala, made some measurements in the north of Sweden at Storlien, a station on the railway from Stockholm to Drontheim, situated near the Norwegian frontier and at an elevation of about 2000 feet above mean sea-level.[4] These observations were carried out with the same instruments which had been used at Upsala. Subsequently further determinations were made by the same method at Mr. A. Lawrence Rotch's Observatory at Blue Hill, near

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[1] Minute of September 8, 1873, and Appendix I. to the Report of this Meeting.

[2] An edition of 60 copies. Upsala, 1879 (published at the expense of the Letterstedt Fund). Second edition, 1881.

[3] "Mesures des hauteurs et des mouvements des nuages, par N. Ekholm et K. L. Hagström," *Acta Soc. Reg. Scient.*, Upsala, 1885. "Die Höhe der Wolken im Sommer zu Upsala," *Meteor. Zeitschr.*, 1887.

[4] "Mesures de nuages faites dans les montagnes de Jemtland pendant l'été de 1887 par K. L. Hagström et A. Falk," *Öfvers. af K. Vet. Akad. Förh.*, 1891.

Boston, U.S.A., by Messrs. Rotch, H. Clayton, and S. P. Fergusson.[1] The details of these observations cannot be here entered into; the results will be discussed below and compared with the newer ones given in the present report.

An international classification of clouds is clearly only possible if the typical forms met with are the same all over the globe. To settle this preliminary question Clement Ley requested a number of English sailors to take cloud observations, according to a nomenclature which he suggested. They were unanimous in declaring that they had experienced no difficulty in distinguishing in all latitudes the various cloud forms according to the classification invented in England.

In addition to this, Ralph Abercromby twice made a voyage round the world with the principal object of observing and photographing clouds. In this way it was established that cloud forms are everywhere identical.[2]

An international nomenclature having thus been shown to be possible, Abercromby came to Upsala in 1886, and we there agreed to propose the following classification :—

Classification of Clouds.

(*a*) Fine-weather clouds, round forms, often with intervals of blue sky.
(*b*) Foul-weather clouds, flat forms, stretched out as a veil.

A. *Upper Clouds.*
- (*a*) 1. Cirrus.
- (*b*) 2. Cirro-stratus.

B. *Intermediate Clouds.*
- (*a*) 3. Cirro-cumulus.
- (*a*) 4. Alto-cumulus.
- (*b*) 5. Alto-stratus.

C. *Lower Clouds.*
- (*a*) 6. Strato-cumulus.
- (*b*) 7. Nimbus.

D. *Clouds formed by ascending currents due to diurnal range of temperature.*
- (*a*) 8. Cumulus.
- (*b*) 9. Cumulo-nimbus.

E. *High Fogs.*
- 10. Stratus.

In February 1887 we read two papers before the Royal Meteorological Society of London,[3] in which we explained this classification and gave the necessary definitions and descriptions.

I also read a report on the classification of clouds before the International Meteorological Conference which met in Paris in 1889.[4] A classification intended for use by observers on land and sea all over the world, and of which the primary object is to enable us to determine the direction of the air currents

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[1] Clayton and Fergusson: "Measurements of Cloud Heights and Velocities," *Annals of the Astronomical Observatory*, Cambridge, Mass., 1892. Also H. Clayton: "Discussion of the Cloud Observations," *ibid.*, 1896.

[2] "On the Identity of Cloud Forms all over the World," *Quart. Journ. Royal Met. Soc.*, vol. **13**, 1887. See also, "Observations on Cloud Movements near the Equator," *ibid.* vol. **14**, 1888.

[3] "Remarks concerning the Nomenclature of Clouds for Ordinary Use," by H. Hildebrandsson; "Suggestions for an International Nomenclature of Clouds," by the Hon. Ralph Abercromby. *Quart. Journal*, vol. **13**, 1887.

[4] *Mémoires du Congrès*, p. 12. Printed separately at Versailles in 1891.

at different levels, must be simple and practical. It is evident that it will no longer answer our purpose if we desire to undertake researches of a more special character. For instance, it would be necessary to give names to all cloud forms dealt with, if we wished to ascertain whether a connexion exists between the various forms of cirrus and the future weather, or if we wished to study the relation between the form, the constitution, and the origin of clouds. But such special researches, which up to now have received but little attention, will only be undertaken by scientists who take special interest in them.[1]

As early as 1888 Messrs. Neumayer and Köppen in Hamburg joined me in the preparation of a Cloud Atlas. It is hardly possible to satisfactorily describe the various cloud forms by words; we are compelled to have resource to diagrams, which enable the observer to compare what he sees in the sky with what he finds in his instructions. It was, however, no easy matter to obtain satisfactory diagrams. The drawings available at the time of which I am writing were as a rule not sufficiently true to nature to be useful as standards of reference. The best ones then published were those of M. Weilbach.[2]

Good photographs are more satisfactory, but photographs do not show colours, and if cloud diagrams are to be of the greatest possible value they must be coloured. Good paintings or well-executed chromo-lithographs are most suitable from this point of view. With this object I requested two artists, Mme. Elise Arnburg and Mlle. Augusta Wigert, to prepare under my supervision a number of oil paintings representing typical cloud forms from nature or from good photographs. Messrs. Neumayer and Köppen also had some coloured diagrams prepared by M. F. Böcker. In the course of a visit which I paid to Hamburg in 1888 we compared our collections and selected a complete series. During the following year these paintings were carefully revised in accordance with suggestions made by M. Weilbach of Copenhagen and by the scientists who met at the International Meteorological Conference in Paris to whom they were submitted. A grant which we received from the directors of the "Lars Hiertas Minne" Fund of Stockholm enabled us to find a publisher for them in the firm of Besthorn Brothers of Hamburg. Thus there appeared in 1890 a *Cloud Atlas* containing ten chromo-lithographic plates and twelve heliotypes, with explanatory text in four languages—English, German, French, and Swedish.

After these preliminaries, the question was again brought before the International Conference which met in Munich in 1891 by M. Neumayer and myself. The Conference, considering that the forms and movements of clouds merited careful study, which would necessitate the co-operation of meteorological organisations and observatories in all countries, adopted the following resolutions:[3]—

(1) The Conference recommends Messrs. Abercromby and Hildebrandsson's classification of clouds.

(2) The *Cloud Atlas* of Messrs. Hildebrandsson, Köppen, and Neumayer should be adopted as the point of departure for arriving at an agreement as to the classification and nomenclature of clouds. A Committee should be nominated to prepare coloured diagrams of suitable size and at moderate cost. The *Cloud Atlas* as well as the other diagrams presented to the Conference should serve as the basis for this work.

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[1] See for instance the interesting investigations carried out during recent years at Berlin by von Bezold, Kassner, and others on the undulations of clouds (Wogen-Wolken).

[2] *Nord-Europas Skyformer*, Copenhagen, 1881; and "Formes des nuages dans l'Europe septentrionale," *Ann. du Bureau Mét. de France, Mémoires divers de* 1880.

[3] Minutes of the Meetings of August 31 and September 2, 1891, and also Appendix VI.

Messrs. Hann, Hildebrandsson, Mohn, Teisserenc de Bort, and Rotch were elected members of this Committee, with power to add to their number by co-option. During the following autumn Messrs. Singer and Weilbach were invited to join the Committee.[1]

(3) The Conference proposes that measurements of the motion and height of clouds be carried out during a period of one year, at a number of stations distributed throughout the world.

(4) The Conference requests M. Hildebrandsson to prepare instructions for the use of observers.

(5) A permanent International Committee should be nominated . . . charged among other matters . . . with the establishment and direction of a number of stations for observing the height and motion of clouds.

The request of the International Committee to prepare instructions for the use of observers was met by issuing two papers, which appeared in the publications of the meteorological observatory of Upsala, viz. :—

(1) H. Hildebrandsson et K. L. Hagström: "Des principales méthodes employées pour observer et mesurer les nuages" (Upsala, Harald Wretman, 1893).

(2) Ph. Äkerblom: "De l'emploi des photogrammètres pour mesurer la hauteur des nuages," *ibid.* 1894. Translated into German, *Meteor. Zeitschr.* 1894.

These two papers deal with all methods then in use for observing clouds, whether they be by direct vision or by the nephoscope; they also include the measurement of their height by the theodolite or by the photogrammeter.

The permanent Cloud Committee and also the Cloud Atlas Committee met at Upsala in August 1894. Messrs Broounof, Fineman, Hagström, Riggenbach, and Sprung were invited to take part in their deliberations. An exhibition of more than 300 reproductions of clouds from various parts of the world had been organised for this meeting, and from these the Cloud Atlas Committee proceeded to select the diagrams to be reproduced in the International Atlas. They also appointed a sub-committee to carry out their publication, and agreed on the definitions and descriptions of the different cloud forms as well as on the instructions to observers. All these decisions, with some minor modifications, received the assent of the permanent Committee.

Thereupon the permanent Committee adopted the following resolution :—

"All central meteorological institutions are invited to arrange for a first series of observations and measurements of clouds during the year from May 1, 1896 to May 1, 1897. Measurements by eye observation or with the nephoscope should be made at as many stations as possible according to the instructions agreed upon; measurement of altitude need only be made at a limited number of stations satisfactorily distributed. The choice of methods and instruments to be used in these researches is left to the directors of the separate institutions."[2]

The Cloud Atlas Sub-Committee, consisting of Messrs. Riggenbach, Teisserenc de Bort, and myself, commenced work immediately. Many difficulties had to be surmounted. After all technical problems had been solved, there remained the

[1] Shortly after this two cloud atlases, in which this classification was adopted, were published in phototype :—
(1) Dr. Karl Singer: *Wolkentafeln.* Munich, 1892.
(2) Fredrico Manucci: *Classificatione delle Nubi*, Specola Vaticana. Rome, 1893.

[2] Minutes of August 23 and 24, 1894, also Appendix VIII., Minutes of the Cloud Atlas Sub-Committee at Upsala.

question of cost. No publisher was willing to sell the *Atlas* except at a very high price. In the end, M. Teisserenc de Bort solved the difficulty by publishing it himself and selling it to the directors of the various meteorological establishments and to sailors at a very low price, frequently far below cost price.

This *International Cloud Atlas* was published in Paris in 1896; it contains definitions and descriptions of the various types of cloud in French, English, and German, with instructions for observing them, also 28 coloured plates.[1]

At the next meeting of the International Meteorological Conference in Paris in 1896 it was found that in several countries many stations had not commenced observations on the date agreed on at Upsala. On the motion of M. Rykatcheff, the following resolution was adopted:—

"It is requested that the observations of clouds be continued at the secondary stations up to the end of the year 1897."

At the request of the Conference, the permanent International Committee nominated the following gentlemen to serve on a new Cloud Sub-Committee: Messrs. Hildebrandsson (President), Mohn, Riggenbach (Secretary), Rotch, Rykatcheff, Sprung, and Teisserenc de Bort.[2] This sub-committee has been occupied with the question of the publication of the results obtained. There can be no doubt that complete uniformity in the form of publication adopted by the various stations is of paramount importance if the observations are to be readily available to their full extent for researches embracing the phenomena of the whole globe. A specimen form was therefore drawn up by the sub-committee and distributed to the various meteorological organisations in January 1898, immediately after the conclusion of the observations.

This form fixed the minimum in the way of data and summaries which in the opinion of the sub-committee was required from each station. It is of course desirable that supplementary data should be given in all cases in which the extent of the observations permits of their addition. The sub-committee have followed the example set by the International Polar Committee, which has decided on a programme which has been uniformly carried out by all expeditions, and has led to excellent results.

The most important results derived from these international researches will be found in the following report.

The General Circulation of the Atmosphere.

All representations of the general movements of the atmosphere published hitherto have been based on theoretical considerations. The prevailing winds at the surface of the earth have long been known fairly accurately, but, with the exception of a few observations on the anti-trade winds made at isolated points, we have been almost completely ignorant of the upper currents of the atmosphere. On the subject of these currents a number of more or less happy hypotheses have been brought forward, which have all been based on the following two fundamental principles:—

(1) The temperature of the air, which depends on the heating influence of the sun, decreases from the equator towards the poles, so that there must exist an upper wind or equatorial current blowing from the equator to the poles, and a lower wind or polar current blowing from the poles to the equator.

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[1] Captain C. D. Sigsbee of the United States Navy has published, through the Hydrographic Office of Washington, an Atlas containing 16 plates for use in the navy, entitled *Illustrative Cloud Forms for the guidance of Observers in the Classification of Clouds*, Washington, 1897.

[2] Minutes of September 21 and 23, and minutes of the meeting of the Cloud Sub-Committee of September 19, 1896.

(2) Whatever be the direction of an atmospheric current, the rotation of the earth causes it to deviate to the right in the northern hemisphere, and to the left in the southern hemisphere.

The former principle was introduced into meteorology by Halley in 1686 to explain the origin of the trade winds, the latter by Hadley in 1735 to explain the fact that the trade winds blow from North-east and South-east, and not from North and South.

According to Dove, the air becomes strongly heated in the equatorial zone, and rises bodily to the higher regions of the atmosphere. The ascending motion thus produced gives rise to a flow of air towards the thermal equator from both sides, and thus we get the trade winds, which skim along the surface of the earth and are directed from temperate regions towards the thermal equator. The masses of air brought to the equator by the trade winds are carried back to the poles by the return currents or anti-trades. Having reached the tropics, these anti-trade winds descend to the surface of the earth, and here, according to Dove, part of the air returns to the equator, thus feeding the trade winds, while part continues its route towards the poles. The South-westerly to Westerly winds which prevail over the temperate oceans of the northern hemisphere, and the North-westerly to Westerly winds of the temperate zones of the southern hemisphere, are regarded by him as the continuation of the anti-trade winds which have descended to the surface. This equatorial current retains the high temperature, great humidity, and low pressure which it derives from its origin over the tropical ocean. To balance the equatorial current which flows towards the polar regions, there must exist a polar current which flows from the polar regions to the tropics. This current is cold and dry, and gives rise to high barometric pressure. The changeable weather of temperate latitudes is due to the continual struggle which is always going on between the equatorial and the polar currents.

Thus we have, according to Dove, two distinct atmospheric circulations in each hemisphere. One of these is very constant, and takes place in a vertical plane between the thermal equator and the tropics; the other is more variable, and takes place almost horizontally between the pole and the tropic. This region is usually divided up among a number of vast oblique bands of air moving in opposite directions. These bands repel and displace each other. The meeting between the opposing currents takes place sometimes at one point, sometimes at another, and ends in one or the other prevailing.

Maury regarded the following generalisations as justified by observation :—

(1) A zone of calms near the equator;

(2) The trade winds or polar currents flowing towards the equator from north and south;

(3) Two regions of calms or light variable winds to the north and south of the trade winds in about latitude 30°;

(4) The anti-trade winds or equatorial currents which descend within these belts of calms and continue their path at the surface of the earth up to latitude 60° or 70°;

(5) Still nearer the poles the contraction of the meridians forces these equatorial winds to ascend and to alter their direction;

(6) Finally they return as upper polar currents and descend to the surface in the region of tropical calms and there form the source of supply for the trade winds.

Thus any given particle of air is continually oscillating from one pole to the other. Starting from the north pole it successively forms part of the upper polar current, the North-east trade wind, and, in the southern hemisphere, the anti-trade wind and the equatorial current, both from the North-west. In the neighbourhood of the south pole, the air rises again and returns to the north

pole, becoming successively an upper polar current, a South-east trade wind, an anti-trade wind from the South-west, and an equatorial current.

The two upper currents—the polar current and the anti-trade wind—meet over the tropical belt of calms, where they cause an accumulation of air and consequent high barometric pressure. But, strange to say, as they descend to the earth's surface the two currents cross without becoming mixed, and each continues on its own path, the one feeding the trade wind, the other the equatorial current. In a similar manner the two trade winds, which have been continually getting warmer and more moist, rise up at the equator and cross, also without mixing in any way. The South-east trade wind, for example, pursues its course in the upper regions of the atmosphere as the anti-trade of the northern hemisphere (Fig. 1., Plate 5).

The theories of Dove and Maury have no adherents among meteorologists of the present. To disprove them we need only point out that the supposition that the equatorial current could retain the high temperature and great humidity, which it derives from the tropical ocean after having risen to the upper regions of the atmosphere as an anti-trade wind, is in direct contradiction to the fundamental laws of the mechanical theory of heat. As a matter of fact, it must become cooled and lose the greater part of its moisture in so ascending. This fact has been established by direct observation as well as from theoretical considerations; we will quote a set of observations which confirm it:—

Messrs. Ångström and Edelstam, while studying the intensity of solar radiation at different altitudes at Teneriffe, frequently had occasion to make simultaneous meteorological observations at different levels.[1] Thus on June 27, 1896, at 9 a.m. they found the following values at Sitio de Cullen at sea-level and on the summit of Pico de Teyde (12,000 ft. = 3692 metres) respectively:—

TABLE I.—Teneriffe.

	Barometer.		Temperature.				Humidity.				
			Dry Bulb.		Wet Bulb.		Absolute.		Relative.	Grains.	Grams.
			F.	C.	F.	C.					
	ins.	mm.					in.	mm.	%	per cub. foot.	per cub. metre.
Base	30·02	762·6	73°·9	+23°·3	67°·5	+19°·7	·571	14·5	68	6·19	14·2
Summit	19·35	491·6	40·5	+ 4·7	25·7	− 3·5	·075	1·9	30	0·87	2·0

Thus the temperature decreases on the average by 1° F. per 350 feet (0°·51 C. per 100 metres), and the humidity is very small at the upper level. Should the air at the summit descend to sea-level, it is evident that it would become heated dynamically, but it would remain very dry—a true Foehn.

In Maury's theory we are also unable to conceive how two air currents can cross without mixing.

Theories subsequently adopted by many meteorologists are those of Ferrel, and James Thomson.

Ferrel brought forward three different theories: the first in 1856,[2] the second in 1860,[3] and the third in 1889.[4] James Thomson[5] published a theory which is almost identical with Ferrel's last one as early as 1857.

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[1] Knut Ångström: "Intensité de la radiation solaire à différentes altitudes. Recherches faites à Ténériffe, 1895 et 1896." *Actes de la Soc. Roy. des Sciences d'Upsala*, 1900.

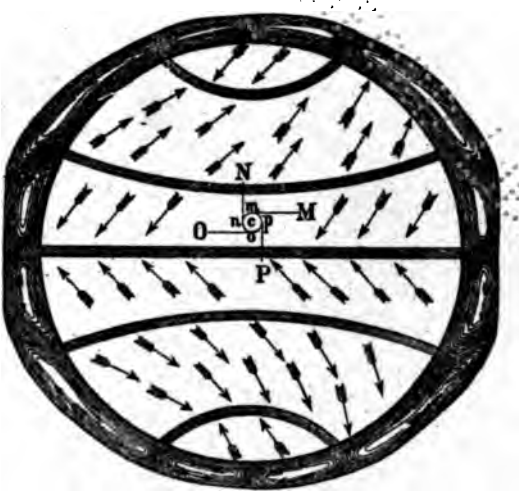
[2] "The Winds and Currents of the Ocean," *Nashville Journal of Medicine and Surgery*, 1856. Reprinted in the *Professional Papers of the U.S.A. Signal Service*, No. XII. i.

[3] "The Motions of Fluids and Solids on the Earth's Surface," *Runkle's Mathematical Monthly*, 1858-60. Reprinted in the *Professional Papers of the U.S.A. Signal Service*, No. VIII.

[4] Ferrel: *A Popular Treatise on the Winds*, p. 155. New York, 1889.

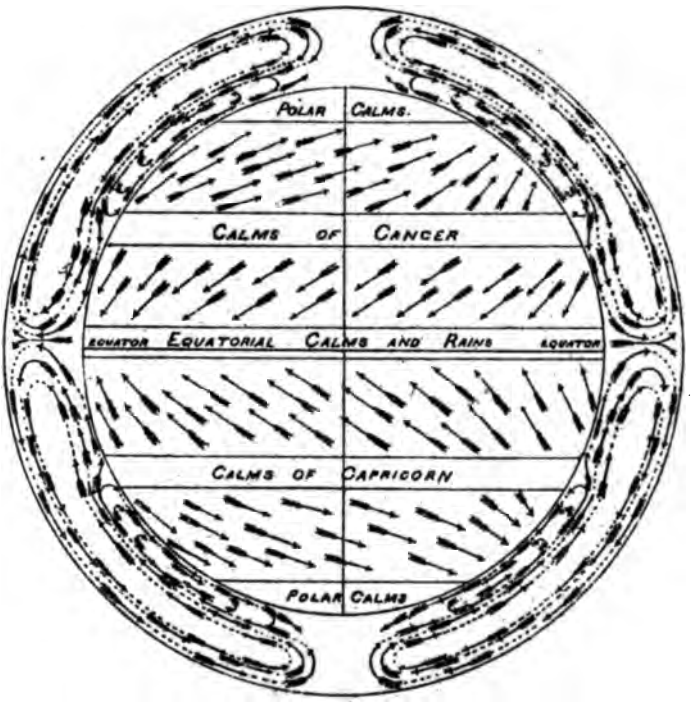
[5] "The Grand Currents of Atmospheric Circulation," *British Assoc. Meeting*, 1857. See also James Thomson's Bakerian Lecture: "On the Grand Currents of Atmospheric Circulation," *Phil. Trans.*, 1892 (printed after the author's death).

Fig. 2.



FERREL—1856.

Fig. 5.



THOMSON—1857.



We do not intend to enter here into the arguments and calculations of these authors; it will be sufficient to state the results which they arrived at.

The conclusions which Ferrel came to in 1856 as the result of lengthy arguments and calculations are shown graphically in Fig. 2, Plate 5. He admitted that there exist two primary regions of high pressure encircling the earth at about 28° north and south of the equator, and two secondary ones at the poles. On the other hand, the equator is a region of permanent low pressure, and there also exist two more marked low-pressure regions near the arctic and antarctic circles. The surface of the earth is thus divided into six distinct zones each having its proper vertical circulation. In the northern hemisphere the air, which is brought to the equator by the trade winds, there ascends and returns as an anti-trade wind to the 28th parellel of latitude where it descends to the earth's surface and recommences the same circulation. On the northern side of the maximum in latitude, 28°, he calculated that the air should move towards the North-east, as it actually does in the prevailing South-westerly winds of the temperate zone. A little to the south of the arctic circle there is a region of minimum barometric pressure. Here the air rises and returns as an upper polar current to the tropical high-pressure area where it descends and recommences the same circulation.

North of the arctic circle he assumed another independent circulation. In this the air descends to the surface at the poles and flows thence towards the arctic circle, where it ascends and returns to the neighbourhood of the pole as an upper current.

Analogous circulations were assumed to be taking place in the southern hemisphere.

In the following year, 1857, James Thomson published a new theory of the grand currents which go to make up the general circulation of the atmosphere in a paper read before the British Association (see Fig. 5, Pl. 5). In this he assumes that there are two main currents superposed on each other in each hemisphere. The air which rises in the neighbourhood of the equator flows as an upper current to the neighbourhood of the arctic circle and returns to the equator as a lower polar current. As observations show that the prevailing surface winds in the temperate zone are from the South-west, he assumes that these latter currents belong only to a thin layer in which a kind of reaction current is produced between the current from the north and the earth's surface. All those currents thus superposed are deviated towards the east and consequently become South-westerly, North-westerly, and South-westerly respectively. We might expect that the polar current would become a North-easterly wind according to Hadley's law, but Thomson assumes that it is deviated to the east "in virtue of a revolutional momentum brought from the equatorial regions, and not yet exhausted."[1]

In his second paper Ferrel showed by very detailed calculations that the general circulation of the atmosphere probably took place in accordance with the scheme represented by Fig. 3, Plate 5.

Finally in 1889 he published the diagram reproduced in Fig. 4, Plate 5, which differs from that by James Thomson in unimportant details only.

This theory of the general circulation of the atmosphere is still held by many meteorologists. It must, however, be admitted that the upper currents which it assumed for the temperate zones are entirely hypothetical. No attempts had been made to prove their existence by direct observation.

Before attempting to study the causes of the general circulation of the atmosphere, we must try to determine what actually takes place in it accurately and independently of all theoretical considerations, *i.e.* we must discover by

[1] *Phil. Trans.* loc. cit. p. 681.

observation what movements are going on in it. The mean direction of the surface wind has long been known for a great many stations in all parts of the world, and, thanks to the co-operation of sailors and to the works of Maury, Brault, and others, our knowledge of the general course of the winds over the oceans is also satisfactorily complete. On the other hand, our knowledge of the upper currents of the atmosphere is very limited. To determine the mean direction of the currents at different altitudes above the level of the ground, we have to fall back on observations of the movements of different forms of clouds. Unfortunately, regular observations of the motion of clouds are very scarce, and in many cases the value of those which we possess is not above criticism. Moreover, we cannot affirm *a priori* that the average observed motion of a particular form of cloud is the same as that of the predominating wind at the same level. It is obvious that we can only determine the direction of the upper currents if there happen to be clouds drifting with them, for without these the currents are invisible, and moreover the observation also becomes impossible when the clouds are hidden by lower clouds. Clearly these conditions are not always attainable.

In spite of these difficulties I have already published several preliminary papers on this question. For Europe I have discussed the observations of the movement of cirrus which have been made at a large number of stations, and from the results, which agree well among themselves, I have drawn the following conclusions :[1]—

1. The mean direction of cirrus clouds is from between North-west and South-west at all stations in Europe and at all seasons of the year.

2. In winter it is from a rather more Northerly point than in summer.

3. The component from the North is especially great in winter over Sweden and on the northern shores of the Mediterranean.

Subsequently these researches were extended and the results discussed in two papers dealing with the mean direction of the upper currents of the atmosphere over the whole globe.[2] In these papers the following results were arrived at :—

1. In the upper regions of the atmosphere over the temperate zones currents whose mean direction is from west to east predominate.

2. Within the tropics the direction of motion is reversed, it is from east to west.

3. The direction of the upper currents seems to agree very closely with the mean direction of motion of the centres of barometric depressions.

4. The mean direction of the upper currents bears no direct relation to the mean distribution of atmospheric pressure at the earth's surface, but when the mean direction of the upper currents and the isobars at a height of 4000 metres (13,000 feet), as determined by Teisserenc de Bort, are plotted on the same chart the agreement is very striking. It is, however, not complete because, among other reasons, cirrus clouds exist at an altitude of from 7000–9000 metres (23,000–30,000 feet), whereas the isobars are drawn for the 4000 metres (13,000 feet) plane. (Plate 6.)

The movement from the East of the upper currents at the equator has now been directly confirmed. The existence of this current had already been shown

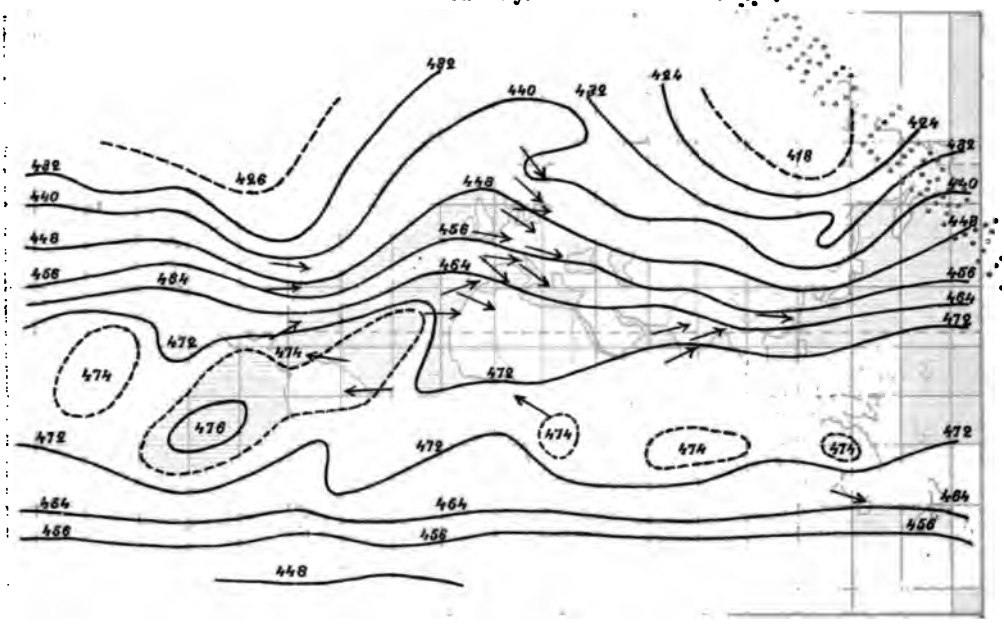
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[1] "The Mean Direction of Cirrus Clouds over Europe," *Quart. Journal Royal Met. Soc.*, vol. 11, p. 287, 1885. See also *Met. Zeitschr.* 1886, and *Ann. de la Soc. Météor. de France*, 1886, p. 295.

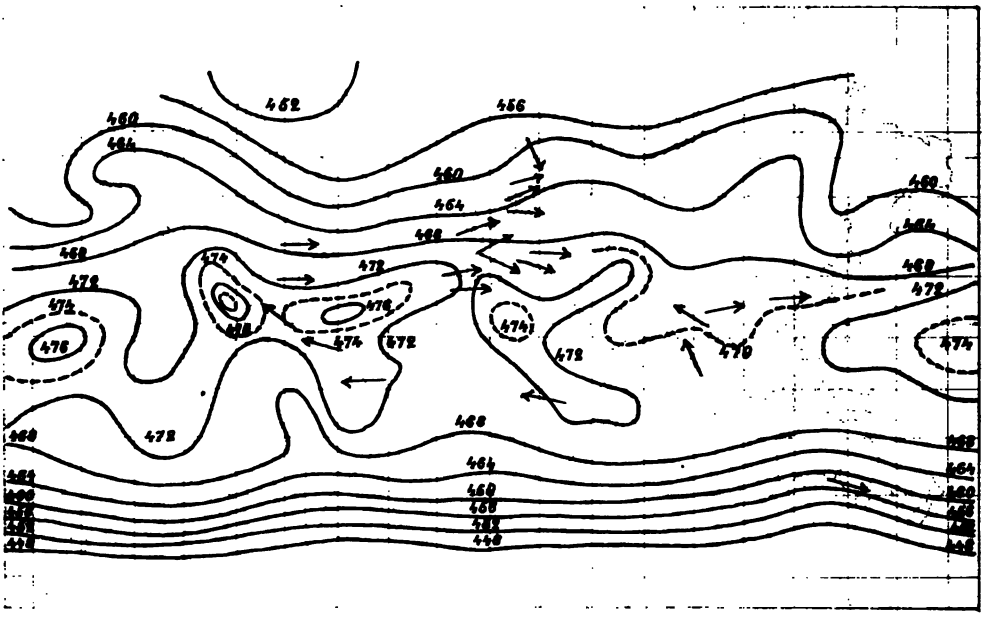
[2] "Sur la direction moyenne des courants supérieurs de l'atmosphere audessus de la surface terrestre." International Meteorological Congress held at Paris September 19 to 20, 1889, *Mémoires*, p. 193 ; and "Ueber den Werth der Messungen von Zugrichtung und Höhe der Wolken für die Meteorologische Wissenschaft.—*Archiv der Deutschen Seewarte*, 1891, No. 5.

Teisserenc de Bort: Isobars at a height of 4600 m.

January.



July.





in a most singular manner during the eruption of Mount Krakatoa in August 1883. The optical phenomena caused by the volcanic dust which was carried up into the uppermost layers of the atmosphere travelled round the world from east to west in about 12 or 13 days, from which it follows that these uppermost currents are endowed with a velocity from the east of 83 miles per hour (37 metres per second). This velocity is very nearly the same as the mean velocity of the upper clouds at Washington, and is therefore not at all inconceivable.

In the following pages the results which have been derived from a discussion of all available observations of the motion of clouds will be given. The mean directions have been determined with the resultantometer of M. Sandström, which gives accurate results to within 1° or 2°.

I.—TROPICAL ZONE.

Observations from the neighbourhood of the equator are unfortunately very scarce. From the Atlantic Ocean the following observations are available:—

(*a*) The mean direction of cirrus cloud is given for each month in a work by Captain H. Toynbee entitled *Meteorological Data for* **Square 3,** *extending from the* **Equator to 10° N. Lat.,** *and from* **20° to 30° W. Long.,** published by order of the Meteorological Council of London, 1874.

In the magnificent collection of simultaneous observations from almost all parts of the globe published by the Signal Office of Washington[1] two columns, unfortunately only occasionally used, are set aside for observations on the direction of upper and lower clouds. From these observations I have calculated the mean direction of upper clouds for each season of the year at—

(*b*) **Paramaribo** (Dutch Guiana) from April 1876 to March 1877; and

(*c*) **Southern West Indian Islands** from December 1877 to November 1878.

(*d*) In the *Meteorological Bulletin* of **San José de Costa Rica** observations of certain kinds of clouds extending over a period of a year and a half are given. From these the mean direction of cirrus has been calculated for each month.

The results are given in Table 2 and on Plate 7. [On this and the subsequent Plates the letters indicate the months, beginning with S for September and ending with O for October. The other letters are: E = summer; P = spring; H = winter; A = autumn.] At Paramaribo, the upper clouds came uniformly from the East; of 270 observations there were only 6 from South-east and 5 from the North-east during the whole year.

TABLE II.—Tropical Atlantic Ocean.

Month.	Square 3.	San José.		Paramaribo.	West Indies.
January	E. 78° S.	E. 10° N.			
February	E. 60 S.	E. 22 S.	Dec. to Feb.	E.	E. 7° S.
March	E. 23 S.	E. 45 N.			
April	E. 18 S.	E. 15 N.			
May	E. 26 S.	E. 73 N.	March to May	E. 1° S.	E. 29 S.
June	E. 7 S.	E. 25 N.			
July	E. 10 S.	E.			
August	E. 32 N.	E. 30 N.	June to August	E. 2 S.	E. 30 S.
September	E. 17 N.	E. 20 N.			
October	E. 20 S.	E. 10 N.			
November	E. 60 S.	E. 17 N.	Sept. to Nov.	E. 1 N.	E. 14 S.
December	E. 15 S.	E. 20 N.			

[1] *International Meteorological Observations taken simultaneously,* 1875-1884.

From some observations made at **Mukimbungu**, Congo Free State, by the Swedish missionaries, from July 1889 to April 1891, the mean direction of cirrus has been calculated as E. 37° S.

Mr. Maxwell Hall gives the following values for **Jamaica**:—upper clouds from East-north-east; intermediate clouds from South-east; and lower clouds from East.[1]

In the Pacific Ocean we have the work of the observatory at **Manila** in the Philippine Islands in lat. 14° 36′ N.[2]

The observations were made during the years 1890-97. The following Table and Plate 8 give the mean direction for each month at four different altitudes. As is customary, cirrus-cumulus are classed with the intermediate clouds.

TABLE III.—MANILA.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Surface Wind.
January	E. 84° S.	E. 10° N.	E. 12° N.	E. 84° N.
February	E. 79 S.	E. 12 N.	E. 10 N.	E. 3 N.
March	E. 73 S.	E. 7 N.	E. 3 N.	E. 13 S.
April	W. 7 S.	E. 4 N.	E. 1 N.	E. 38 S.
May	E. 17 N.	E. 11 S.	E. 18 S.	W. 75 S.
June	E. 15 N.	E. 29 S.	E. 50 S.	E. 65 S.
July	E. 14 N.	W. 35 S.	W. 36 S.	W. 43 S.
August	E. 6 N.	W. 36 S.	W. 34 S.	W. 39 S.
September	E. 27 N.	W. 24 S.	W. 21 S.	W. 41 S.
October	E. 43 S.	E. 12 N.	E. 16 N.	E. 76 N.
November	E. 21 S.	E. 1 S.	E. 7 N.	E. 51 N.
December	E. 35 S.	E. 5 N.	E. 8 N.	E. 58 N.

From this it appears that the monsoon of the surface extends into the region of the intermediate clouds, *i.e.*, to a height of 16,000 to 24,000 feet (5000 to 7000 metres); cirrus and cirro-stratus on the other hand move from East to West in all months except April.

The observations from the Atlantic Ocean and from Manila in the Pacific Ocean both teach us that *the upper currents in the tropical zone move, almost without exception, from East to West.* Observations are not sufficiently numerous to enable us to discuss the question why the direction of motion is at times slightly more from the North-east and at times slightly more from the South-east; we must be satisfied with ascertaining the fact that the general movement over the thermal equator is from East to West.

II.—TRADE WIND ZONE.

It has long been admitted that the anti-trade winds blow from the South-west in the northern hemisphere and from the North-west in the southern hemisphere, and it has even been assumed, as we saw above, that they are continued in the upper regions of the atmosphere up to the arctic circle.

In the Atlantic Ocean there is not a single station in the central region of the trade wind zone. To make up for this we have the excellent observatory at **Mauritius**, in the region of the South-east trade wind of the Indian Ocean. From the official report of the director, Mr. T. F. Claxton, for the year 1897,[3] the average monthly drift of the upper clouds and surface winds for the years

[1] *Clouds and Cloud-drift and Thunderstorms in Jamaica.* Jamaica, 1896.

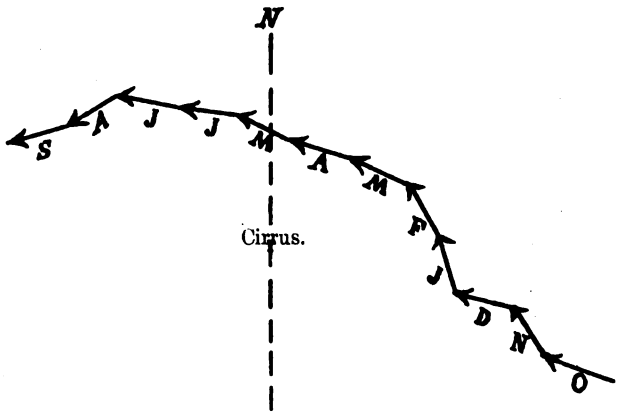
[2] Rev. Father José Algué: *Las Nubes en el archipiélago Filipino. Collaboración al trabajo internacional de medición de nubes.* Manila, 1898, p. 34.

[3] *Colony of Mauritius, Annual Report of the Royal Alfred Observatory for the year* 1897, p. 2.

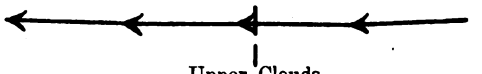
AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

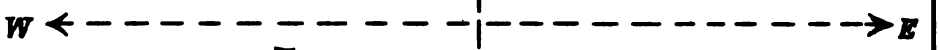
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a. Square No: 3. Atlantic Ocean { 0°—10° Lat. N. / 20°—30° Long. W. Gr.

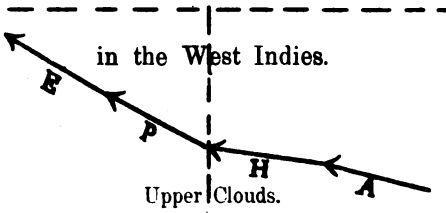


b. at Paramaribo.

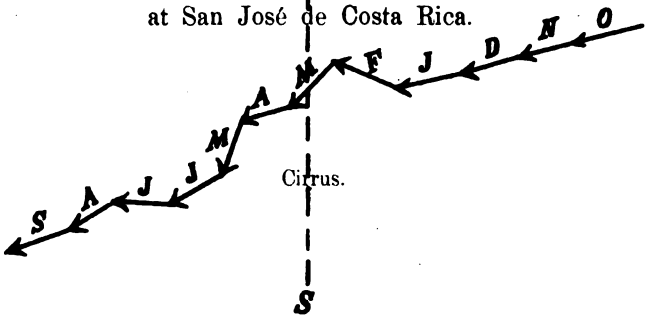




c. in the West Indies.



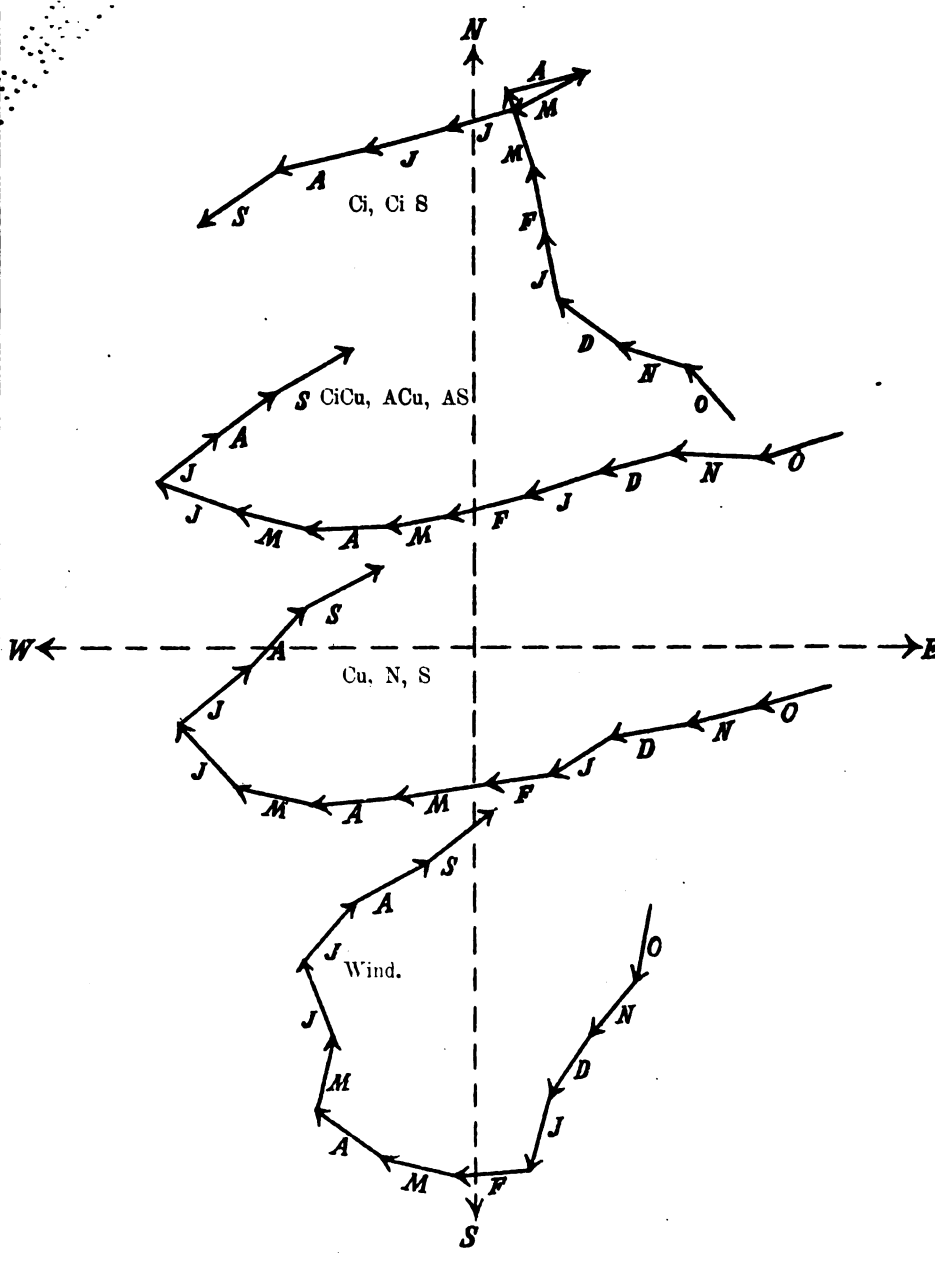
d. at San José de Costa Rica.



AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

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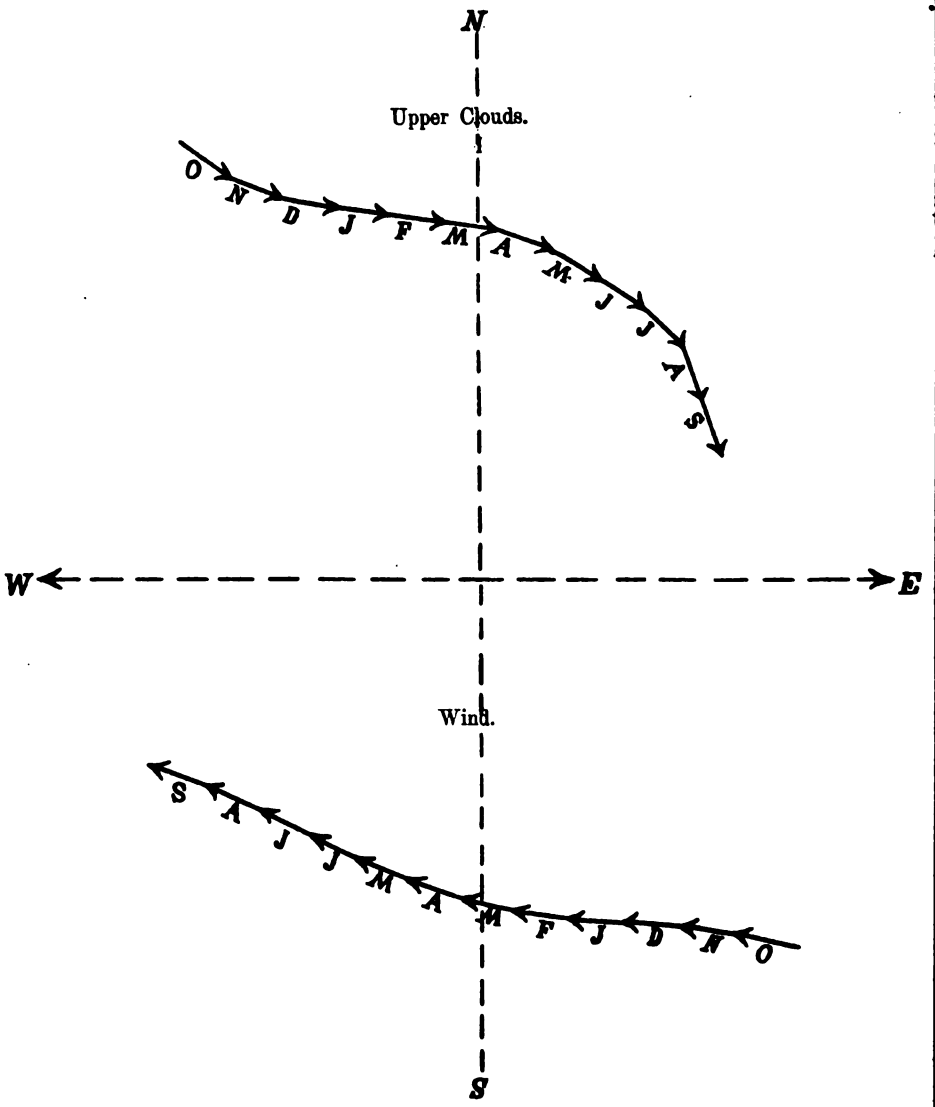
Manila.



AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

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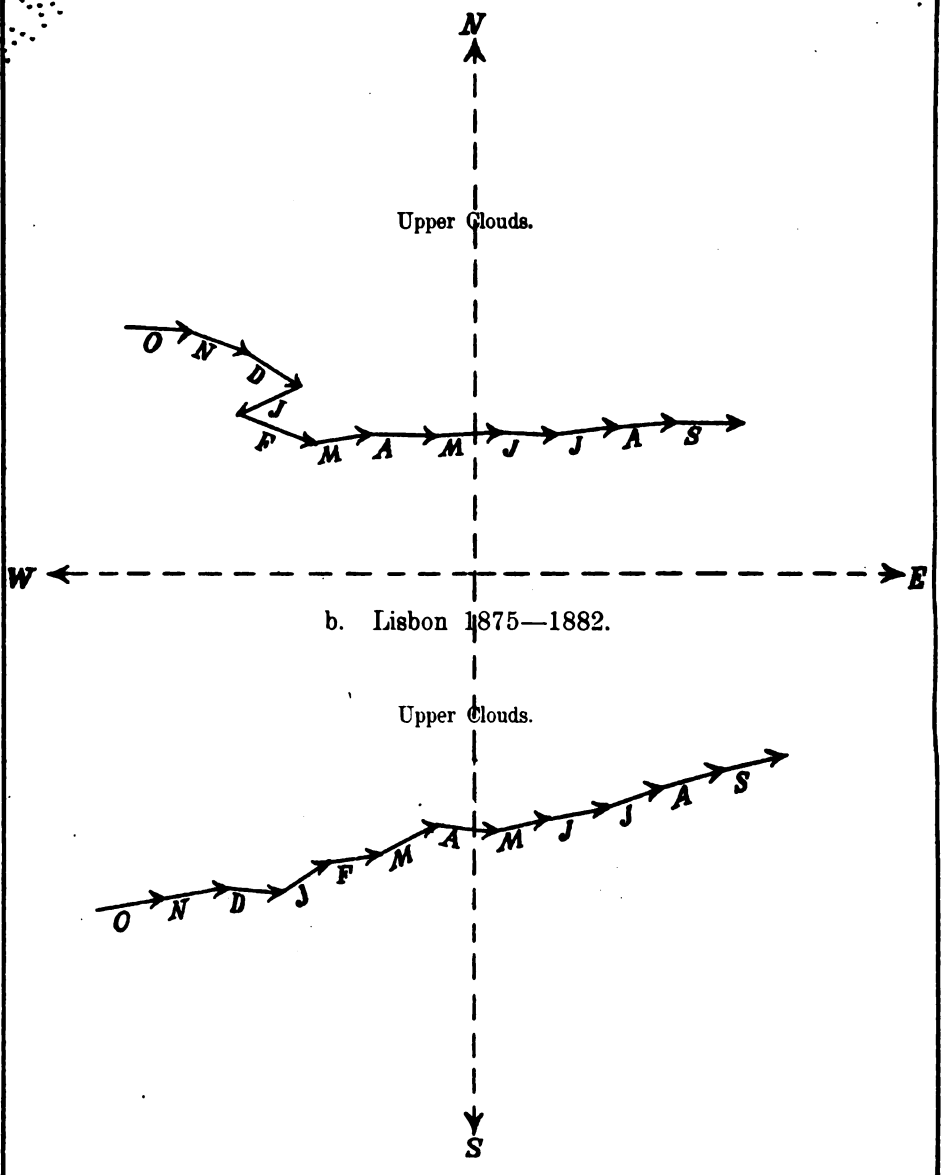
Mauritius 1877—1897.



AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

a. San Fernando 1876—1885.



b. Lisbon 1875—1882.

1877 to 1897, have been abstracted. The total number of observations of upper clouds dealt with is 3393 (see also Plate 9).

TABLE IV.—MAURITIUS.

Month.	Cirrus.	Wind.	Month.	Cirrus.	Wind.
January . .	N. 82° W.	S. 87° E.	July . . .	N. 43° W.	S. 65° E.
February . .	N. 80 W.	S. 80 E.	August . .	N. 15 W.	S. 67 E.
March . .	N. 83 W.	S. 78 E.	September . .	N. 20 W.	S. 71 E.
April . . .	N. 68 W.	S. 72 E.	October . .	N. 48 W.	S. 78 E.
May . . .	N. 61 W.	S. 64 E.	November . .	N. 70 W.	S. 82 E.
June . . .	N. 60 W.	S. 61 E.	December . .	N. 78 W.	E.

From this Table it will be seen that at Mauritius, which is situated in the centre of the trade wind regions, the anti-trade wind blows approximately from the North-west. It is, therefore, probable that the upper wind in the region of the trade winds of the northern hemisphere blows from the South-west.

In the theories of Ferrel and Thomson this upper wind was supposed to continue, at any rate in the main, as an upper wind until it reached the neighbourhood of the poles. We shall see that this hypothesis is erroneous.

As a matter of fact the anti-trade wind of the northern hemisphere, like all other winds, becomes deviated to the right, and by the time it reaches the northern limits of the trade wind it has become a wind from the West. As is well known, this deviation increases with the altitude, so that an upper current is deviated to the right of a lower current, a fact which has been confirmed by direct observation of the movements of superposed layers of cloud.

At **Teneriffe** the wind at the summit is almost always from South-west. Cirrus clouds are very rare. Nevertheless, I have received from Puerto de la Orotava forty observations made by Prof. Hj. Öhrvall between January and May 1884, and thirty-seven observations made by Lieut. Gustave Hultcrantz in November and December 1886. These observations distribute themselves as follows :—

N.	N.N.W.	N.W.	W.N.W.	W.	W.S.W.	S.W.	S.S.W.
1	1	6	6	**27**	6	7	2
S.	S.S.E.	S.E.	E.S.E.	E.	E.N.E.	N.E.	N.N.E
5	3	5	3	2	0	2	1

Thus at the altitude of cirrus cloud the mean direction of the wind over Teneriffe in winter is from W. 15° S.

The Director of the Royal Naval Observatory of Spain, Captain C. Pujazon, has sent me an MS. copy of the regular observations of cirrus cloud made at **San Fernando** (36° 37′ N. lat.) during the ten years 1876-1885. This town, which is situated at the western end of the Straits of Gibraltar, is within the northern limit of the trade wind throughout the year, except perhaps in January.

Table 5 gives the results of the cloud observation (see also Plate 10, *a*).

TABLE V.—SAN FERNANDO.

Month.	Cirrus.	Month.	Cirrus.
January	E. 30° N.	July	W. 4° S.
February	W. 24 N.	August	W. 3 S.
March	W. 8 S.	September	W. 4 N.
April	W. 7 N.	October	W. 3 N.
May	W. 3 S.	November	W. 20 N.
June	W. 3 N.	December	W. 35 N.

We see, therefore, that the anti-trade wind is deviated more and more to the right in the northern hemisphere, and by the time it reaches the northern

limit of the trade wind in the neighbourhood of the region of highest pressure its direction of motion has become from nearly due West.

From **Lisbon** (38° 42′ N. lat.) Admiral de Brito Capello has sent me an MS. copy of the regular observations of the movements of cirrus cloud made between February 1875 and December 1882. The results are given in Table 6 and in Plate 10, *b*.

TABLE VI.—LISBON.

Month.	Cirrus.	Month.	Cirrus.
January	W. 34° S.	July	W. 20° S.
February	W. 10 S.	August	W. 16 S.
March	W. 28 S.	September	W. 13 S.
April	W. 10 N.	October	W. 8 S.
May	W. 17 S.	November	W. 12 S.
June	W. 10 S.	December	W. 6 S.

Probably we ought to look upon this station as being at times within the most northerly boundaries of the anti-trade winds, and at times under the influence of the upper winds of the temperate zone.

It is well known that the trade-winds and the high-pressure areas by which they are caused show an annual oscillation, being displaced with the sun from north to south, and *vice versa*. A broad band on the northern side of the thermal equator is covered in winter by the North-east trade-wind, and in summer by the belt of tropical calms. At higher altitudes the anti-trade wind from the South-west and the tropical current from the East alternately prevail over this area; it is, in fact, a region of *upper* monsoons. The following observations furnish examples of this variation: (*a*) **Square No. 39,** which extends from **10° to 20° N. lat.,** and from **20° to 30° Long. W. Gr.**[1] For this square, which lies immediately to the north of Square No. 3, Toynbee gives the following directions for the motion of the upper clouds (Plate 11, *a*):—

TABLE VII.—SQUARE No. 39 (10°–20° N. and 20°–30° W.).

Month.	Cirrus.	Month.	Cirrus.
January	W. 29° S.	July	E. 24° S.
February	W. 47 S.	August	E. 5 N.
March	W. 50 S.	September	E. 65 S.
April.	E. 43 N.	October	E. 64 S.
May	W. 77 N.	November	W. 62 S.
June	E. 32 S.	December	W. 63 S.

The annual variation is here very marked, the anti-trade wind prevails in winter, and the current from the East in summer.

(*b*) **Mexico.**—Observations of the direction of upper and lower clouds at a number of stations in Mexico, extending over several years, are given in the *International Simultaneous Observations*, published by the Signal Office from 1875 to 1884. In preparing the following Table the returns from those stations which lie between Mazatlan in the north-west and Vera Cruz in the south-east, *i.e.* between 23° 20′ and 19° 11′ N. lat., have been utilised. As the number of stations is very variable in the different years the observations have been compounded as though they all had reference to a single station. The results are given in Table 8 and Plate 11, *b*.

The upper monsoon is thus shown to be well developed in Mexico. The wind at the surface is very variable in so mountainous a country. Its mean direction for each month has been calculated for Mazatlan, which is situated on a plain bordering the Pacific Ocean. During the cold season, a trade wind

[1] H. Toynbee, *Meteorological Data for Nine Ten-degree Squares.* London, 1876. Meteorological Office Publication, Official No. 27.

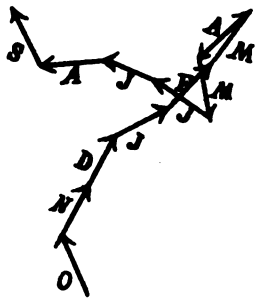
AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

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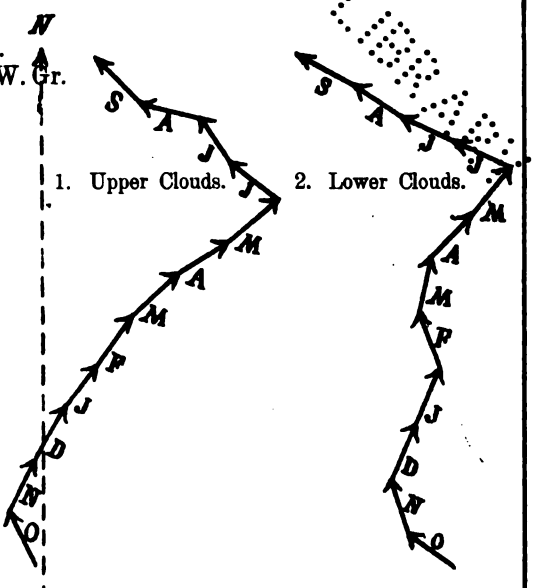
a. Square No: 39.

Atlantic Ocean { 10°—20° Lat. N. / 20°—30° Long. W. Gr.

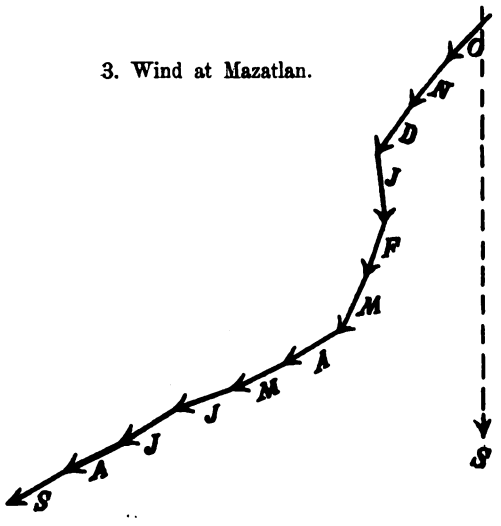
Upper Clouds.



b. Mexico (1881—83).

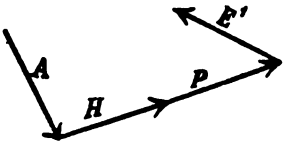


3. Wind at Mazatlan.



c. Havana (Cuba).

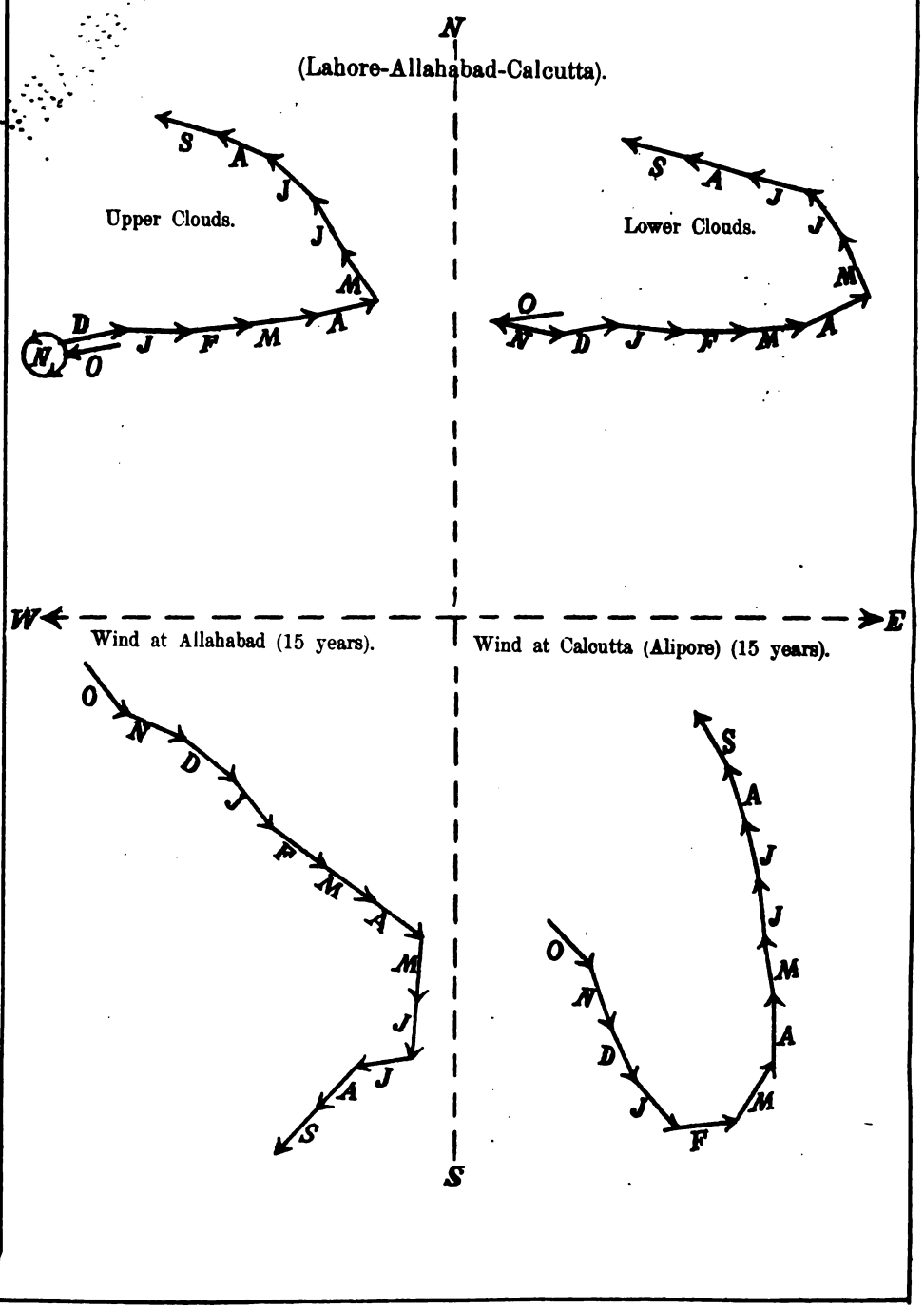
Upper Clouds.



AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

in

Northern India.



from North-east prevails; in summer this becomes deviated to the right and blows from between East-north-east and East.

TABLE VIII.—Mexico.

Month.	Upper Clouds.	Lower Clouds.	Wind at Mazatlan.
January	W. 55° S.	W. 64° S.	W. 80° N.
February	W. 53 S.	E. 67 S. (?)	E. 70 N.
March	W. 40 S.	W. 76 S.	E. 60 N.
April	W. 32 S.	W. 44 S.	E. 33 N.
May	W. 37 S.	W. 52 S.	E. 23 N.
June	E. 36 S.	E. 24 S.	E. 19 N.
July	E. 57 S.	E. 23 S.	E. 33 N.
August	E. 14 S.	E. 35 S.	E. 26 N.
September	E. 48 S.	E. 25 S.	E. 30 N.
October	E. 63 S.	E. 37 S.	E. 46 N.
November	W. 63 S.	E. 70 S.	E. 63 N.
December	W. 62 S.	E. 68 S.	E. 55 N.

(*c*) **Havana.**—(Cuba) (23° 9′ N. Lat.). For this station the mean direction of the upper clouds has been calculated for each season from the *International Simultaneous Observations* published by the Signal Office.

Autumn	N. 31° W.	Spring	W. 21° S.
Winter	W. 15 S.	Summer	E. 26 S.

The anti-trade wind from the South-west therefore prevails over Havana in winter and spring, in summer it is replaced by the tropical current from the East. In autumn the upper wind from the North-west, which, as we shall see below, prevails over the sub-tropical zone, extends as far south as Havana. (Plate 11, *c*.)

III.—INDIA.

The circulation of the wind in the region of the Indian monsoons and over the Arabian Sea is very complex. India is separated from the rest of Asia by a chain of mountains of which the summits are above the mean height of the upper clouds. On the southern side of these mountains, in the valley of the Ganges the monsoons are greatly deviated. In winter the wind in this region blows from North-west, instead of from North-east; in summer the monsoons from the South-west becomes a wind from the South in the northern parts of the Bay of Bengal, it ascends the valley of the Ganges as a South-easterly wind, and finally at Allahabad it blows from the North-east. These irregularities exist even in the upper regions of the atmosphere.

Nephoscope observations carried on for thirteen years at **Calcutta** and **Allahabad** have yielded the following results:[1]—

	Jan.-March.	April-June.	July-Sept.	Oct.-Dec.
Calcutta	S. 84° W.	S. 47° W.	S. 14° E.	S. 78° W.
Allahabad	S. 86 W.	S. 86 W.	S. 27 E.	S. 77 W.

As there is no trade wind in summer on the northern side of the equator in these regions, we cannot speak of an anti-trade wind, but an upper wind from the West prevails over Central India from Kurachee to Cuttack, throughout almost the whole year. In Assam the upper wind blows from the West throughout the year.

These statements are proved by the following tables which contain the results of the observations on the direction of upper and lower clouds given in the *Simultaneous International Observations* published by the Signal Office.

[1] *Indian Meteorological Memoirs*, vol. 4, part 8, p. 545.

In Table 9 the observations from the most northerly stations—Lahore, Roorhee, Agra, Lucknow, Allahabad, Patna, Hazaribagh, and Calcutta—and in Table 10 those from Kurachee, Deesa, Bombay, Poona, Belgaum, Nipur, Jubbelpore, and Cuttack have been compounded. Both Tables refer to the period October 1877 to November 1879. (See also Plates 12 and 13.)

TABLE IX.—Northern India.

Month.	Upper Clouds.	Lower Clouds.	Wind (15 years). Allahabad.	Calcutta.
January	W. 2° N.	W. 9° N.	W. 56° N.	W. 52° N.
February	W. 9 S.	W. 5 S.	W. 24 N.	W. 9 S.
March	W. 5 S.	W. 5 S.	W. 25 N.	W. 58 S.
April	W. 15 S.	W. 29 S.	W. 38 N.	W. 87 S.
May	E. 55 S.	E. 68 S.	E. 82 N.	E. 79 S.
June	E. 63 S.	E. 50 S.	E. 88 N.	E. 86 S.
July	E. 42 S.	E. 14 S.	E. 6 N.	E. 79 S.
August	E. 25 S.	E. 17 S.	E. 50 N.	E. 73 S.
September	E. 14 S.	E. 14 S.	E. 48 N.	E. 63 S.
October	E. 10 N.	E. 2 N.	W. 48 N.	W. 42 N.
November	irregular.	W. 10 N.	W. 25 N.	W. 73 N.
December.	W. 10 S.	W. 10 S.	W. 36 N.	W. 64 N.

TABLE X.—Central India.

Month.	Upper Clouds.	Lower Clouds.	Wind. Bombay (10 years).	Cuttack (15 years).
January	W. 3° N.	E. 40° N.	E. 84° N.	E. 45 N.
February	W. 3 N.	E. 35 S.	W. 86 N.	W. 74 S.
March	W. 15 S.	E. 35 S.	W. 62 N.	W. 74 S.
April	W. 20 S.	E. 15 S.	W. 38 N.	W. 73 S.
May	W. 47 S.	E. 70 S.	W. 8 N.	W. 85 S.
June	W. 54 S.	W. 17 S.	W. 27 S.	W. 59 S.
July	W. 15 S.	W. 20 S.	W. 15 S.	W. 46 S.
August	E. 2 N.	W. 15 S.	W. 9 S.	W. 46 S.
September	E. 4 S.	W. 15 S.	W. 1 S.	W. 80 S.
October	W. 4 S.	E. 85 S.	E. 75 N.	E. 58 N.
November	W. 2 S.	E. 50 S.	E. 73 N.	W. 89 N.
December.	W. 35 S.	E. 65 S.	E. 73 N.	E. 78 N.

In **Assam** a wind from the West prevails in the region of the upper clouds throughout the year. The following are the actual values found :—

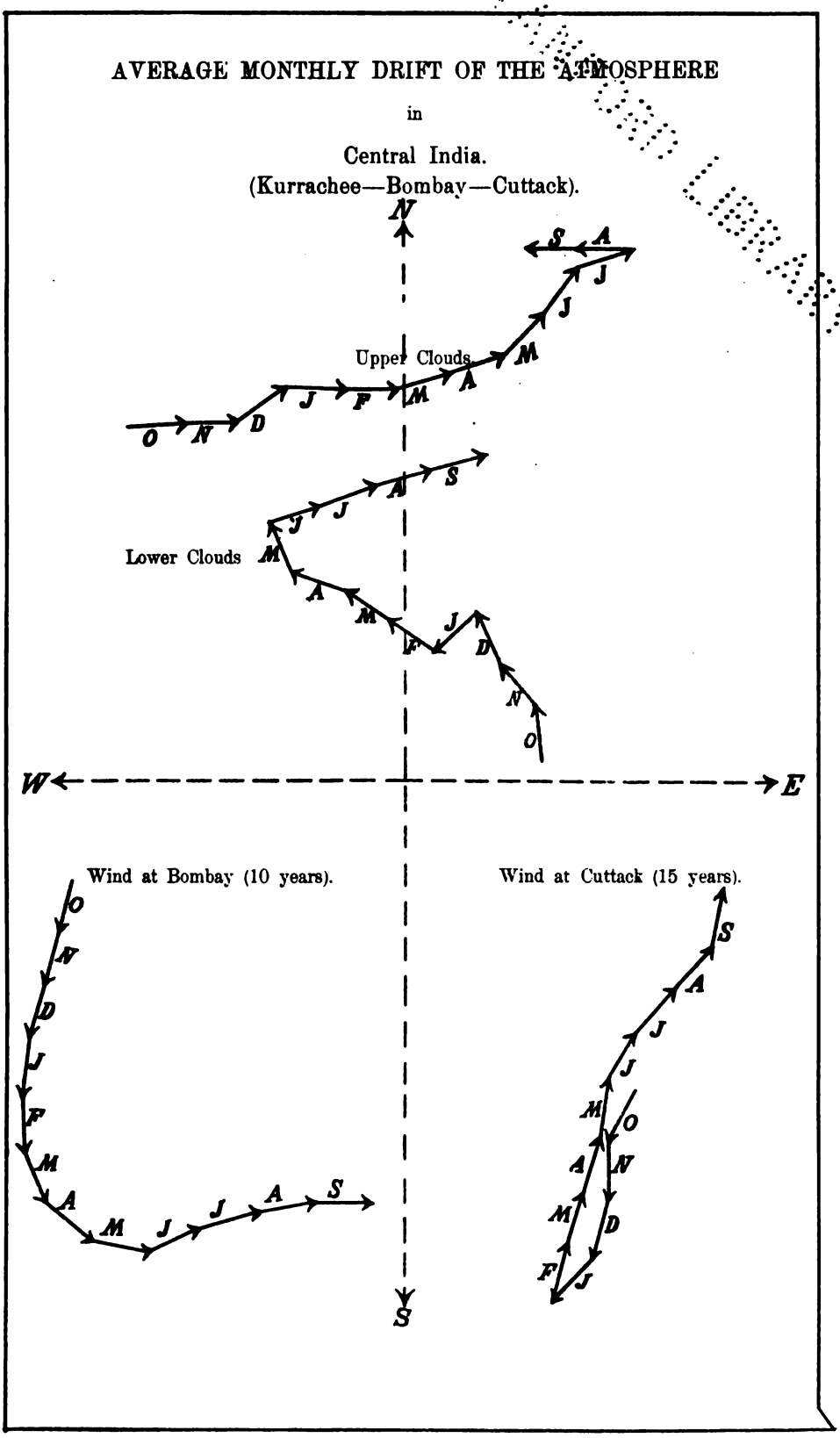
Winter	W. 13° S.	Summer	W. 9° S.
Spring	W. 12 S.	Autumn	W. 9 S.

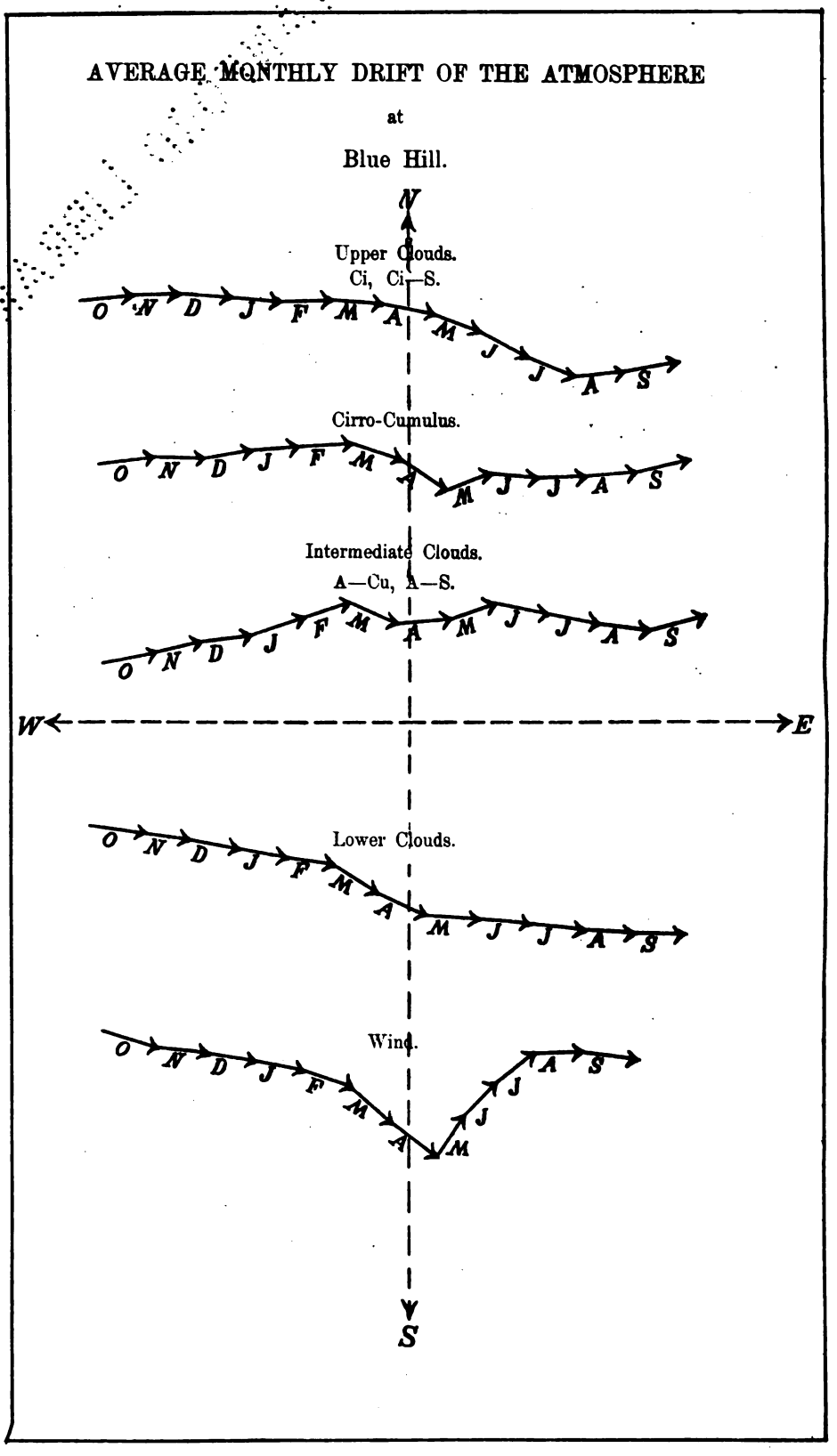
For the **Arabian Sea** Dallas has published the following values for the different seasons :[1]—

TABLE XI.—Arabian Sea.

1. December to February.				2. March to May.			
Latitude.	Wind.	Upper Clouds.	Cirrus.	Latitude.	Wind.	Upper Clouds.	Cirrus.
32°–28°	N. 22° W.	N. 45° W.	N. 45° W.	32°–28°	N. 79° W.	N. 68° W.	N. 68° W.
28–24	S. 12 E.	N. 56 W.	...	28–24	N. 66 W.	N. 82 W.	N. 56 W.
24–20	N. 67 W.	N. 45 W.	...	24–20	S. 87 W.	S. 77 W.	S. 72 W.
20–16	N. 2 W.	N. 69 W.	N. 67 W.	20–16	N. 40 E.	S. 85 W.	N. 50 W.
16–12	N. 39 E.	N. 31 W.	N. 33 E.	16–12	N. 41 E.	S. 87 E.	S. 47 E.
12– 8	N. 39 E.	N. 81 E.	N. 82 E.	12– 8	N. 24 E.	N. 56 W.	S. 81 W.
8– 4	N. 45 E.	N. 69 E.	N. 58 E.	8– 4	N. 52 W.	W.	S. 27 E.
4– 0	N. 18 E.	N. 34 E.	N. 34 E.	4– 0	S. 64 W.	S. 85 W.	S. 82 W.

[1] W. L. Dallas: "Upper Currents of Air over the Arabian Sea," *Quart. Jour. Royal Met. Soc.*, vol. **19**, p. 239.


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
in
Central India.
(Kurrachee—Bombay—Cuttack).
N
S
W
E
Upper Clouds
Lower Clouds
Wind at Bombay (10 years).
Wind at Cuttack (15 years).


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Blue Hill.
N
Upper Clouds.
Ci, Ci—S.
O N D J F M A M J J A S
Cirro-Cumulus.
O N D J F M A M J J A S
Intermediate Clouds.
A—Cu, A—S.
O N D J F M A M J J A S
W
E
Lower Clouds.
O N D J F M A M J J A S
Wind.
O N D J F M A M J J A S
S

3. JUNE TO AUGUST.

Latitude.	Wind.	Upper Clouds.	Cirrus.
32°–28°	...	...	...
28–24	...	...	...
24–20	N. 67° W.	...	...
20–16	S. 64 W.	N. 7° E.	S. 59° E.
16–12	S. 50 W.	N. 82 E.	N. 65 E.
12– 8	S. 50 W.	S. 45 E.	S. 54 W.
8– 4	S. 57 W.	S. 56 W.	S. 39 W.
4– 0	S. 51 W.	S. 28 W.	S. 82 W.

4. SEPTEMBER TO NOVEMBER.

Latitude.	Wind.	Upper Clouds.	Cirrus.
32°–28°	N. 45° W.	N. 45° W.	...
28–24	W.	N. 72 W.	N. 35° W.
24–20	S. 34 E.	N. 45 W.	S. 67 W.
20–16	N. 37 E.	N. 65 E.	N. 18 W.
16–12	N. 59 E.	S. 17 E.	S. 23 E.
12– 8	S. 86 W.	N. 49 W.	W.
8– 4	S. 87 W.	N. 12 W.	N. 20 W.
4– 0	S. 49 W.	N. 18 E.	N. 41 W.

To the south of the Bay of Bengal the mean direction of cirrus clouds between 0° and 10° S. Lat. from November to February is S. 31° E. and between 0° and 10° N. Lat. it is S. 39° W.[1]

Thus in winter in the Indian Ocean the thermal equator with its upper current from the East is situated to the south of the geographical equator, a fact, which is the cause of the monsoon from the North-west in these latitudes. In the Arabian Sea the upper current from the East is found in the spring in 4°–16° N. Lat., it is transferred in summer to the north of the Tropic of Cancer and returns in autumn towards the equator. However, its position varies and seems to be different in different years; the material at present at our disposal does not admit of our studying the question in greater detail.

IV.—THE TEMPERATE ZONES.

The Rev. Father Marc Dechevrens in 1885 first showed that the mean direction of motion of the upper clouds in the temperate zone is always from the West.[2] As has already been stated, I showed in the same year (1885) that the same was true for Europe and some other parts of the temperate zones. The large amount of material now available admits of a more detailed discussion of the point.

For America we have in the first instance the excellent observations from Mr. Rotch's Observatory at **Blue Hill**[3] (Table 12 and Plate 14).

TABLE XII.—BLUE HILL, MASS., U.S.A.

Month.	Ci., Ci.-S.	Ci.-Cu.	A.C., A.S.	Lower Clouds.	Surface Wind.
January	W. 4° N.	W. 4° S.	W. 19° S.	W. 8° N.	W. 10° N.
February	W. 1 S.	W. 2 S.	W. 16 S.	W. 9 N.	W. 20 N.
March	W. 5 N.	W. 21 N.	W. 27 N.	W. 34 N.	W. 41 N.
April	W. 14 N.	W. 38 N.	W. 7 S.	W. 23 N.	W. 39 N.
May	W. 22 N.	W. 22 S.	W. 16 S.	W.	W. 63 S.
June	W. 28 N.	W. 5 N.	W. 14 S.	W. 8 N.	W. 43 S.
July	W. 20 N.	W. 3 S.	W. 11 N.	W. 9 N.	W. 36 S.
August	W. 4 S.	W. 3 S.	W. 7 N.	W. 5 N.	W.
September	W. 13 S.	W. 14 S.	W. 15 S.	W. 1 N.	W. 11 N.
October	W. 5 S.	W. 5 S.	W. 6 S.	W. 6 N.	W. 18 N.
November	W. 2 S.	W. 3 N.	W. 16 S.	W. 7 N.	W. 7 N.
December	W. 6 S.	W. 14 S.	W. 7 S.	W. 10 N.	W. 11 N.

[1] *Indian Meteorological Memoirs*, vol. 4, part 8, p. 543.

[2] *Mouvements des couches élevées de l'atmosphere à Zi-ka-wei, déterminés par la direction des Cirri* (Zi-ka-wei, 1885). See also: "Mouvements des diverses couches de l'atmosphere," *Mem. della Pontif. Accad. dei. nuovi Lincei*, vol. 11, 1896.

[3] H. Helm Clayton: "Discussion of the Cloud Observations," *Ann. of the Observatory of Harvard College*, vol. 30, pt. iv. p. 404.

From the *International Simultaneous Observations* published by the Signal Office, the mean direction of the upper clouds has been calculated for a number of stations in **Canada**.

Winter.	Spring.	Summer.	Autumn.
W. 8° N.	W. 14° N.	W. 3° S.	W. 12° N.

For Europe we possess a large number of observations.

Paris.—From the Observatory at Parc Saint Maur, near Paris, my late colleague, M. E. Renou, sent me a MS. copy of the very detailed observations on the motion of the different forms of clouds made during the five years 1876-80. The results which have been computed from these observations are given below (Table 13 and Plate 15, *a*). As the classification then adopted by M. Renou differs somewhat from the present international classification, I have grouped his cirrus and cirro-stratus together as upper clouds.

TABLE XIII.—PARIS.

Month.	Upper Clouds.	Lower Clouds.	Month.	Upper Clouds.	Lower Clouds.
January	W. 25° N.	E. 58° N.	July	W.°	W. 18° S.
February	W. 9 N.	W. 14 S.	August	W. 28 S.	W. 30 S.
March	W. 13 N.	W. 40 S.	September	W. 2 S.	W. 10 S.
April	W. 18 S.	W. 25 S.	October	W. 17 S.	W. 4 N
May	W. 13 S.	W. 11 S.	November	W. 4 N.	W. 15 S.
June	W. 23 S.	W. 33 S.	December	W. 7 S.	W. 6 S.

England.—My fellow-worker in the study of clouds, Rev. W. Clement Ley, had organised a network of stations for the observation of clouds in England, and he had the kindness to send me copies of all observations made during the years 1875-89. The number of stations varied considerably during these years. As a general rule, only cirrus was observed. From the data from all the stations, with the exception of two or three in Ireland and Scotland, I have calculated the following mean values (Table 14, Plate 15, *b*):—

TABLE XIV.—ENGLAND.

Month.	Cirrus.	Month.	Cirrus.
January	W. 2° N.	July	W. 11° N.
February	W. 16 N.	August	W. 5 N.
March	W. 21 N.	September	W. 1 N.
April	W. 9 N.	October	W. 9 N.
May	W. 5 S.	November	W. 15 N.
June	W. 3 N.	December	W. 58 N.

Germany.—In the publications of the Meteorological Institute of Berlin, a number of observations of cirrus cloud are given; from these the following average monthly mean values for a period of five years have been calculated (Table 15, Plate 15, *c*):—

TABLE XV.—GERMANY.

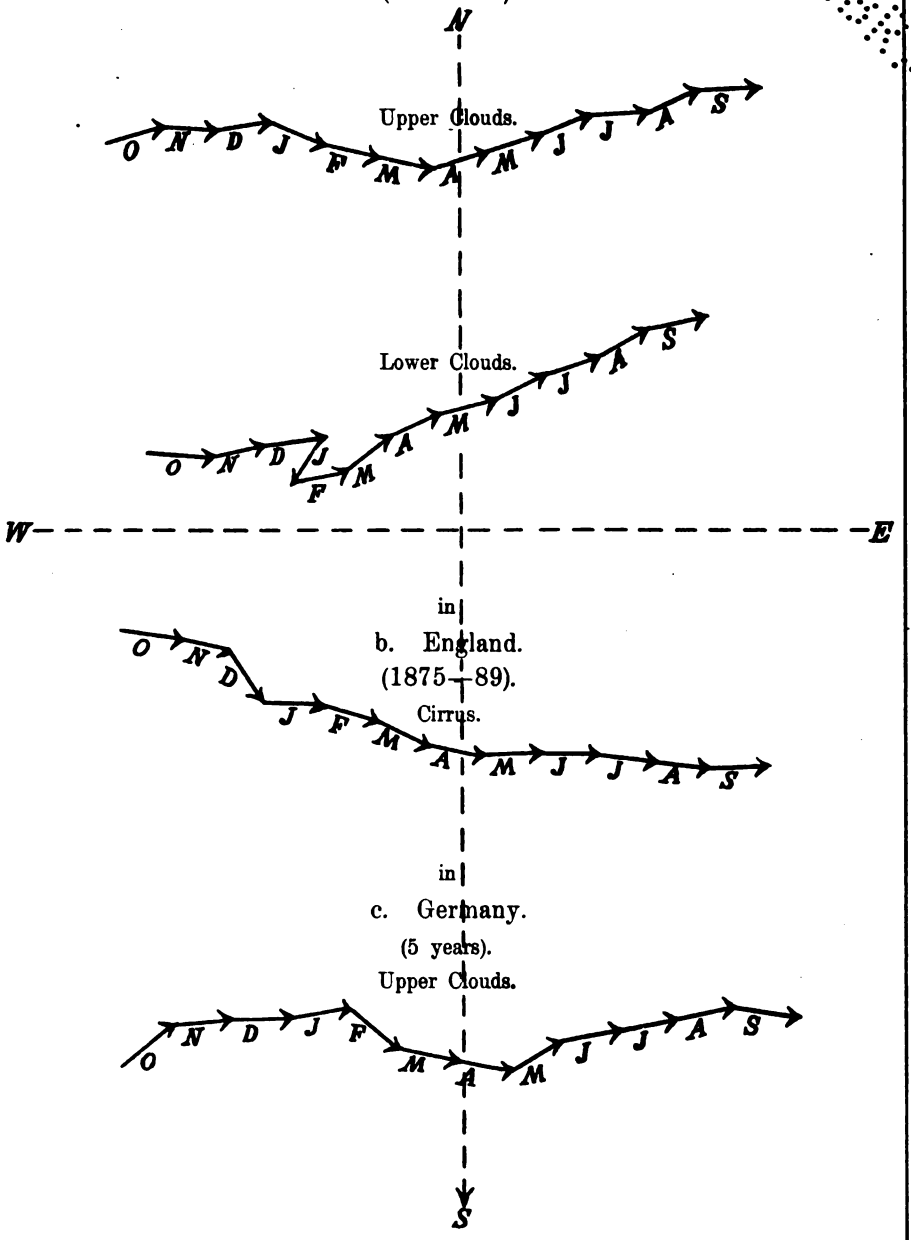
Month.	Cirrus.	Month.	Cirrus.
January	W. 7° S.	July	W. 12° S.
February	W. 42 N.	August	W. 13 S.
March	W. 11 N.	September	W. 6 N.
April	W. 15 N.	October	W. 35 S.
May	W. 36 S.	November	W. 5 S.
June	W. 8 S.	December	W. 2 N.

From **Aarhus** (56° 9′ N. lat.) in **Denmark**, and **Hinnerup**, a few miles north-west of Aarhus, M. H. Nielsen has sent me a MS. copy of some excellent observations made at Aarhus from 1886 to 1889, and at Hinnerup from 1890

AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

a. Paris (Parc Saint Maur).
(1876—80).



in

b. England.
(1875—89).
Cirrus.
O N D J F M A M J J A S

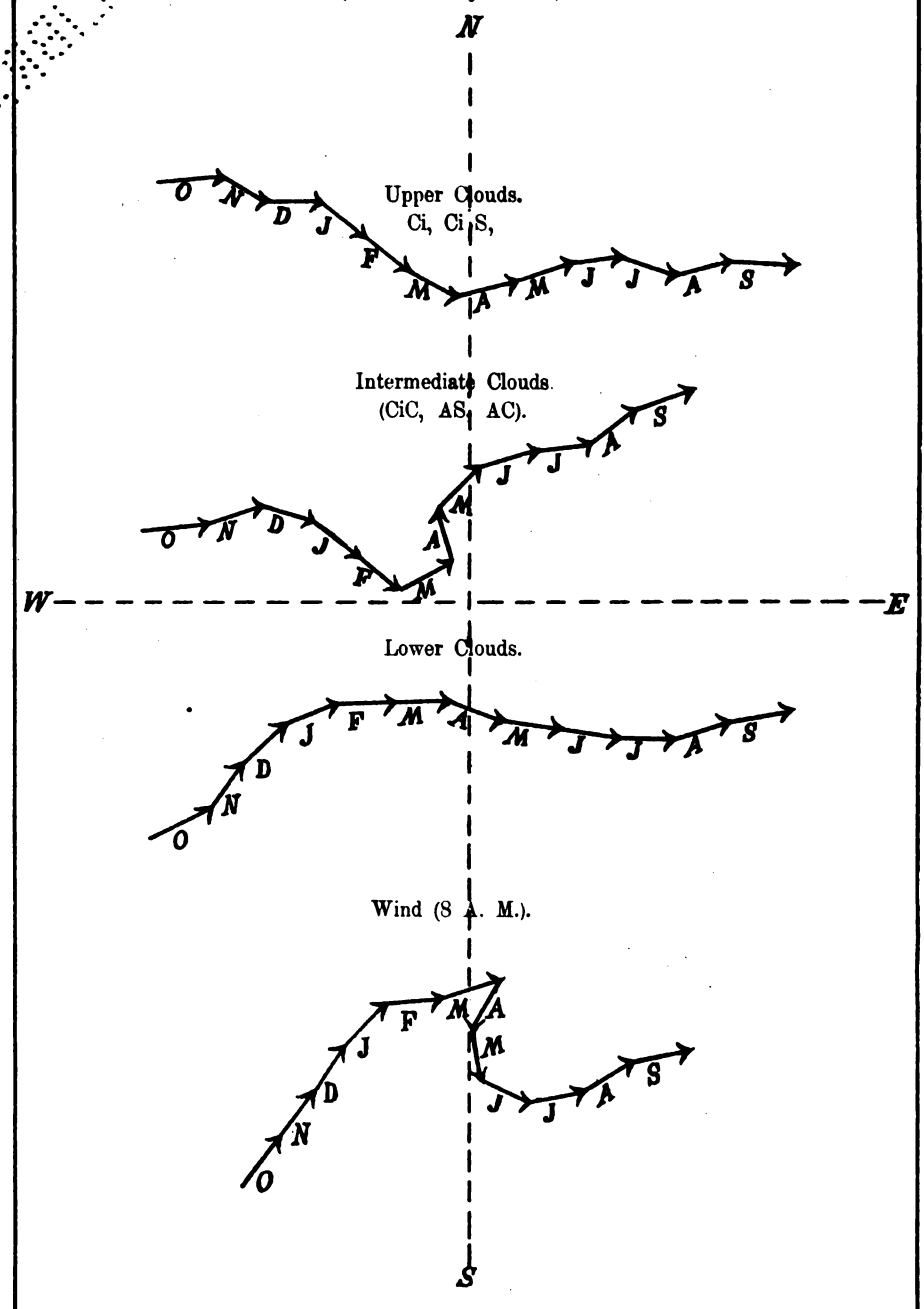
in

c. Germany.
(5 years).
Upper Clouds.
O N D J F M A M J J A S

AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

Aarhus and Hinnerup (Denmark).
(1886—July 1900).



to 1900. M. Nielsen noted the movements of the various forms of clouds, classified on the system in use at Upsala in 1886,—a classification which differs from the one adopted internationally in 1891 only in a few minor points,—three times a day. This series of observations is therefore one of the most complete which we possess. The results for the fifteen years are given in Table 16 and on Plate 16.

TABLE XVI.—DENMARK.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Wind at 8 a.m.
January	W. 39° N.	W. 40° N.	W. 22° S.	W. 42° S.
February	W. 36 N.	W. 39 N.	W. 1 N.	W. 7 S.
March	W. 27 N.	W. 32 S.	W. 5 S.	W. 20 S.
April	W. 15 S.	E. 75 S.	W. 24 N.	E. 60 N.
May	W. 18 S.	W. 44 S.	W. 2 N.	W. 85 N.
June	W. 5 S.	W. 16 S.	W. 8 N.	W. 20 N.
July	W. 10 N.	W. 5 S.	W. 3 S.	W. 16 S.
August	W. 11 S.	W. 37 S.	W. 17 S.	W. 33 S.
September	W. 4 N.	W. 17 S.	W. 9 S.	W. 10 S.
October	W. 6 S.	W. 10 S.	W. 36 S.	W. 53 S.
November	W. 30 N.	W. 20 S.	W. 50 S.	W. 54 S.
December	W.	W. 18 S.	W. 42 S.	W. 57 S.

Upsala (59° 51′ N. lat.).—In a paper entitled "L'Étude internationale des Nuages," 1896-97 (*La Suède*, 3, p. 6), I have calculated the mean direction of the wind for each month, from July 1, 1882 onwards, for four different levels, viz. : (1) the surface of the earth, (2) the level of the lower clouds, (3) the level of the intermediate clouds, (4) the level of the upper clouds. The following Table (17) gives the results (see also Plate 17) :—

TABLE XVII.—UPSALA.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Wind.
January	W. 41° N.	W. 22° N.	W. 5° S.	W. 32° S.
February	W. 43 N.	W. 46 N.	W. 6 S.	W. 5 S.
March	W. 25 N.	W. 28 N.	W. 22 N.	S. 37 W.
April	W. 8 N.	W. 3 N.	W. 51 N.	N. 34 E.
May	W. 12 N.	W. 8 S.	W. 5 N.	E. 20 S.
June	W. 11 N.	W. 1 N.	W. 19 N.	N. 1 W.
July	W. 24 S.	W. 19 S.	W. 21 S.	S. 25 W.
August	W. 17 S.	W. 13 S.	W. 12 S.	S. 33 W.
September	W. 23 N.	W. 5 N.	W. 17 S.	W. 32 S.
October	W. 7 N.	W. 13 N.	W. 38 S.	S. 38 W.
November	W. 41 N.	W. 25 N.	W. 23 S.	W. 38 S.
December	W. 36 N.	W. 32 N.	W. 31 S.	S. 39 W.

The wind at the surface is in general from the South-west, except in April (North-east) and June (North). In May its direction is extremely variable, but an approximate mean can be obtained by extending the calculation over a long period.

At the level of the lower clouds the prevailing winds are little changed. Here also the mean direction is from South-west or West-south-west except in spring, March to June, when it is from West-north-west. At the level of the intermediate and upper clouds the wind directions are also very much alike, but they are very different from those which prevail in the lower layers of the atmosphere. Throughout the layer between 13,000 and 33,000 feet (4000–10,000 metres) the wind from the West has a Northerly component of varying magnitude, except in July and August. During the latter months it blows from between South and West at all altitudes.

The tendency for the upper currents to blow from a more Northerly direction in winter than in summer, which may already be discerned in Denmark, is

found to be general in Sweden, and it becomes more pronounced the farther north we go.

At **Nora** (59° 32′ N. lat.), situated to the west of Upsala, M. C. G. Löwenhielm observed the movements of cirrus during the twenty-three years 1876–98. From these excellent observations I have calculated the following mean values (see also Plate 18, *a*) :—

TABLE XVIII.—NORA, SWEDEN.

Month.	Cirrus.	Month.	Cirrus.
January	W. 49° N.	July	W. 8° S.
February	W. 32 N.	August	W. 1 S.
March	W. 30 N.	September	W. 9 N.
April	W. 12 N.	October	W. 14 N.
May	W. 2 N.	November	W. 33 N.
June	W. 4 S.	December	W. 29 N.

From **Sundsvall** (62° 24′ N. lat.), on the **Gulf of Bothnia**, we have also a long series (1884–97) of observations of the motion of all forms of clouds carried out by the well-known meteorologist M. S. Hjeltström, Professor at the Lycée of that town. On several occasions the observations were discontinued during August in the absence of the observer. Here are the results (Table 19 and Plate 18, *b*) :—

TABLE XIX.—SUNDSVALL.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.
January	W. 23° N.	W. 24° N.	W. 6° N.
February	W. 34 N.	W. 30 N.	W. 14 N.
March	W. 28 N.	W. 40 N.	W. 58 N.
April	W. 10 N.	W. 23 N.	W. 48 N.
May	W. 7 S.	W. 8 S.	W. 29 N.
June	W. 2 N.	W. 20 S.	W. 37 N.
July	W. 30 S.	W. 20 S.	W. 21 S.
August	W. 5 S.	W. 40 S.	W. 50 N.
September	W. 15 N.	W. 7 N.	W. 14 N.
October	W. 15 N.	W. 17 N.	W. 2 N.
November	W. 30 N.	W. 11 M.	W. 15 S.
December	W. 45 N.	W. 70 N.	W. 21 S.

The observations from Nora and Sundsvall therefore confirm those from Upsala.

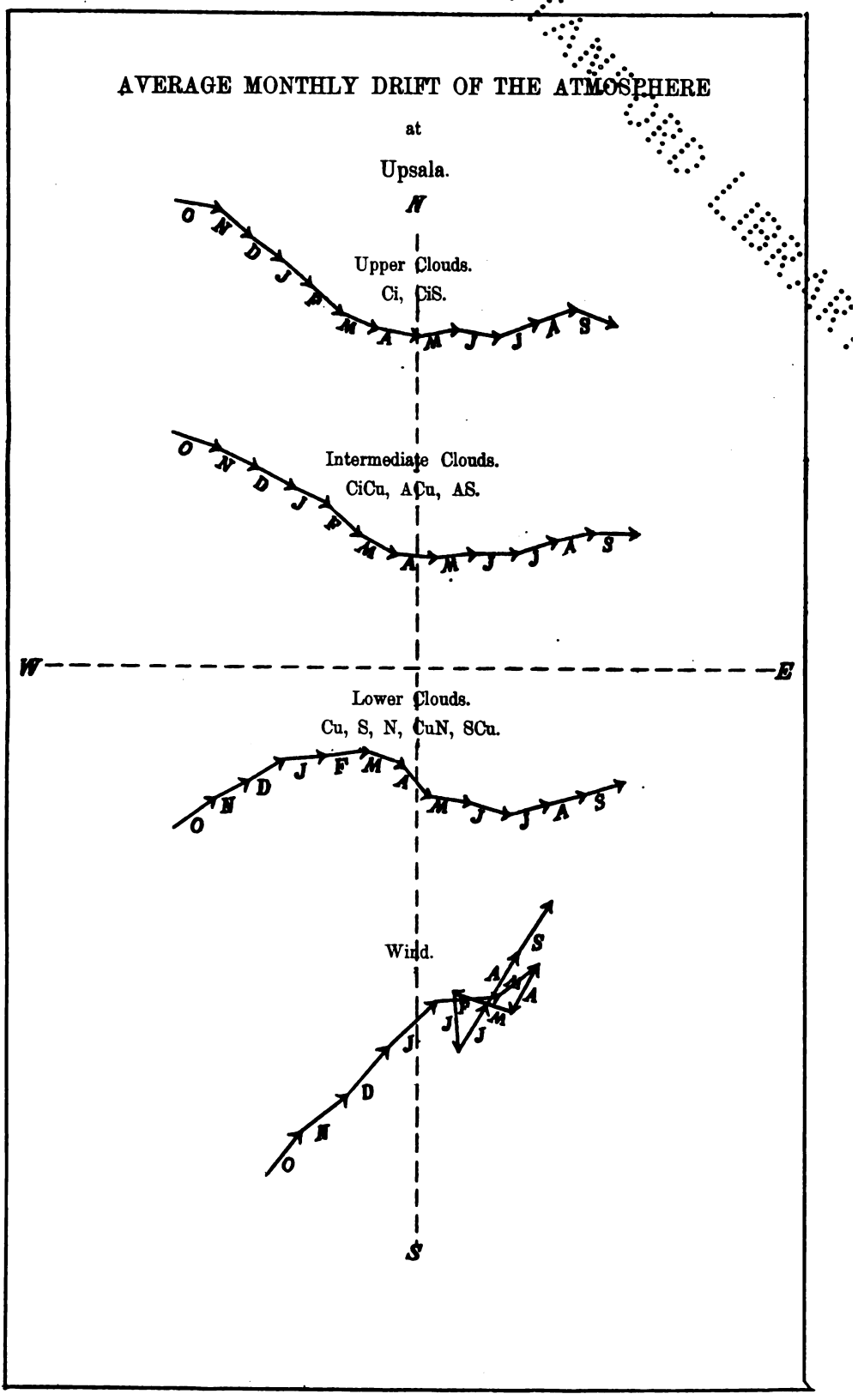
From **Lapland** M. T. Berlin has sent me a series of observations (1874–82) on the motion of cirrus made at first at **Qvickjock** (66° 57′ N. lat.), and later on at **Arjeploug**, which is situated 7 miles south of Qvickjock. The two series have been considered as one, and in the following Table the wind observations from **Jockmock**, an official Swedish station situated midway between the two above mentioned stations, have been added (see also Plate 19, *a*).

TABLE XX.—LAPLAND.

Month.	Cirrus.	Wind.	Month.	Cirrus.	Wind.
January	W. 50° N.	W. 23° S.	July	W. 27° N.	E. 11° N.
February	W. 44 N.	W. 10 S.	August	W. 42 N.	E. 40 N.
March	W. 43 N.	W. 13 N.	September	W. 60 N.	E. 20 S.
April	W. 47 N.	W. 25 N.	October	W. 36 N.	W. 15 N.
May	W. 43 N.	W. 78 N.	November	W. 47 N.	W. 43 N.
June	W. 45 N.	W. 7 S.	December	W. 80 N.	W. 5 S.

The peculiar variations of the surface wind are in complete agreement with the distribution of atmospheric pressure for each month.[1] Above these variable winds a steady current from North-west prevails throughout the year.

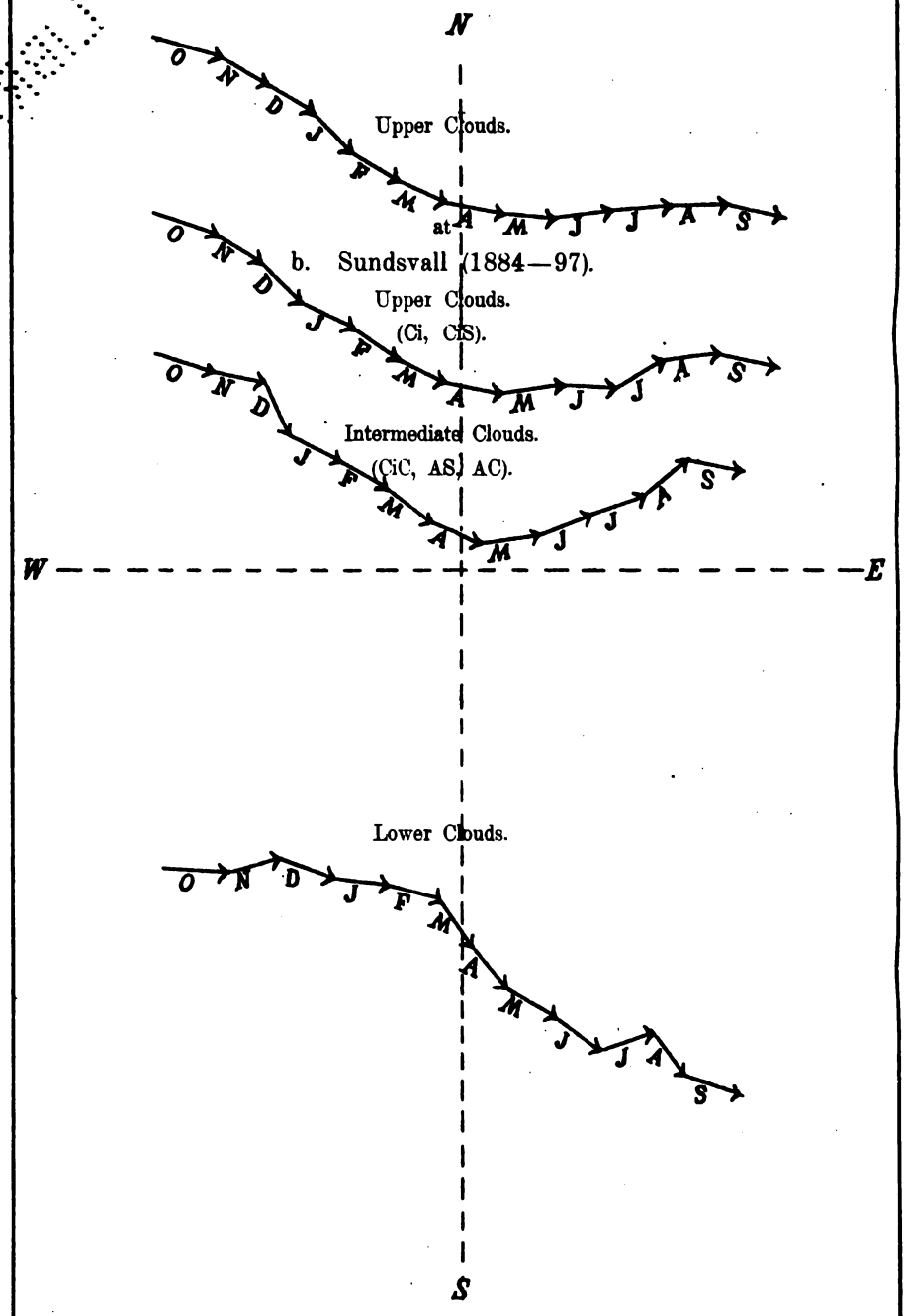
[1] H. E. Hamberg: "La pression atmosphérique moyenne en Suède, 1860–95," *Mémoires de l'Acad. Roy. des Sc. de Suède*, vol. 31. 1898.


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Upsala.
N
Upper Clouds.
Ci, CiS.
O N D J F M A M J J A S
Intermediate Clouds.
CiCu, ACu, AS.
O N D J F M A M J J A S
W
E
Lower Clouds.
Cu, S, N, CuN, SCu.
O N D J F M A M J J A S
Wind.
O N D J J F M A M J J A S
S

AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

a. Nora (Sweden).
1876—1898.



at

b. Sundsvall (1884—97).

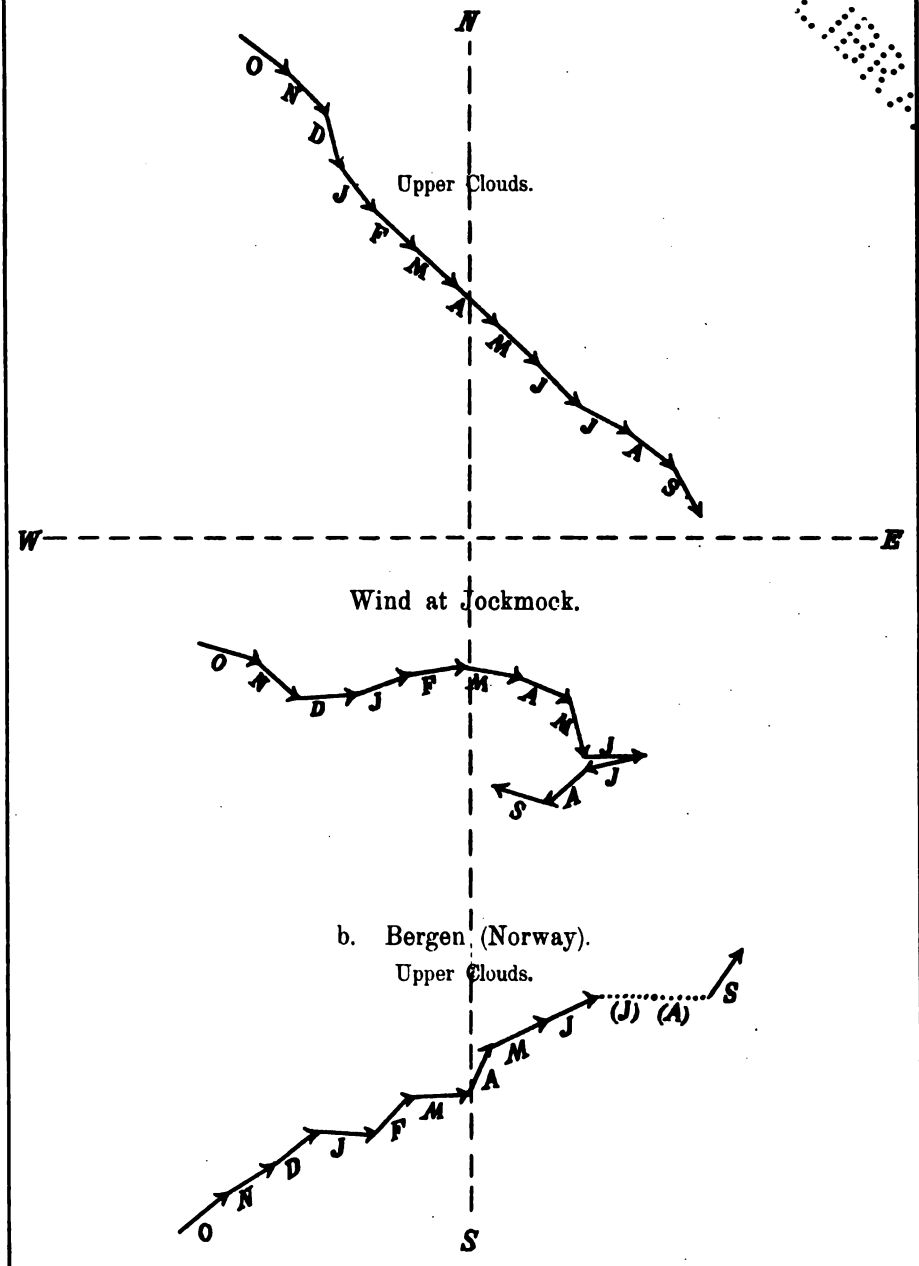
Upper Clouds.
(Ci, CiS).

Intermediate Clouds.
(CiC, AS, AC).

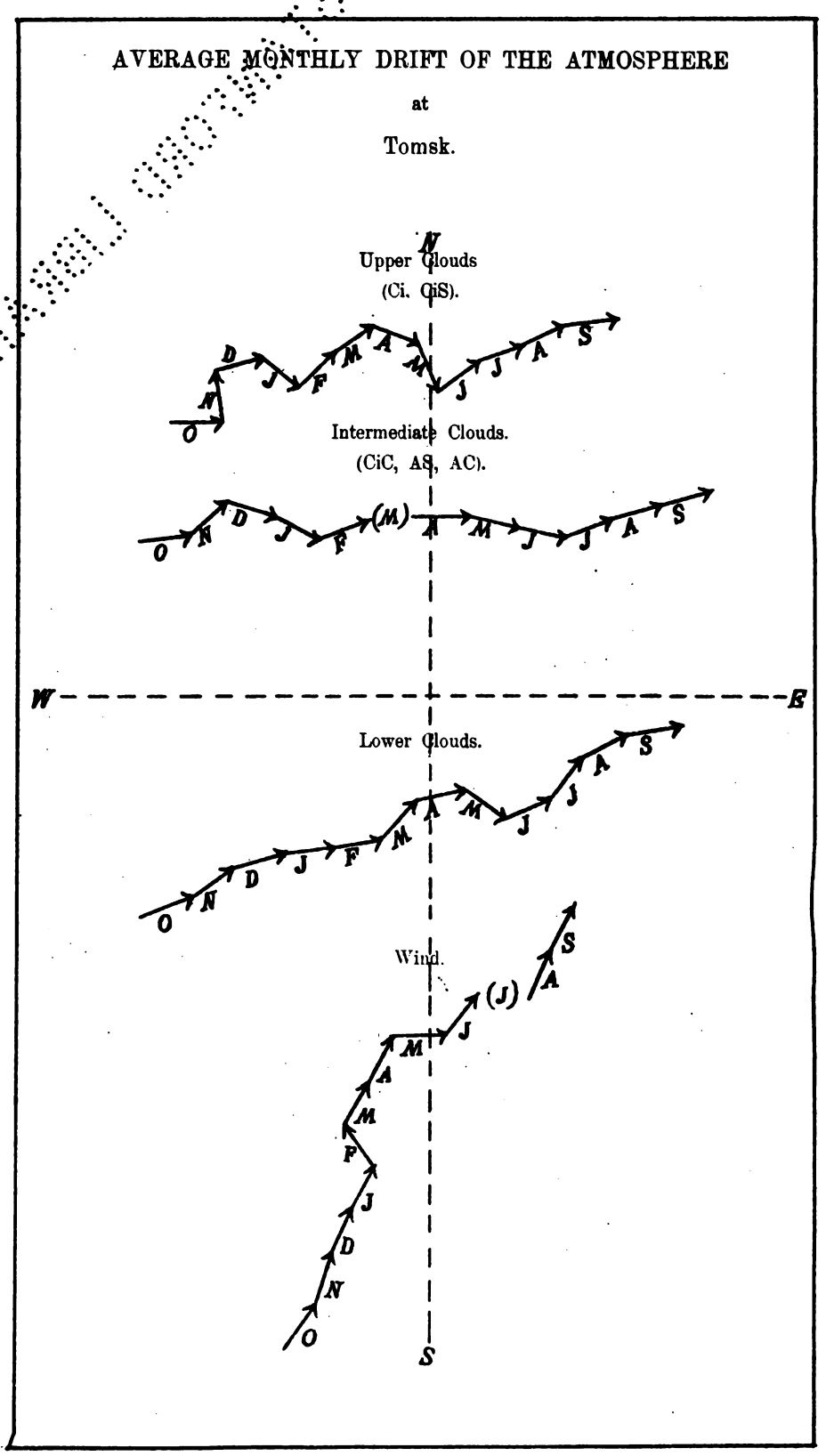
AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

in

a. North Swedish Lapland
(1874—82).



b. Bergen (Norway).


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Tomsk.
N
Upper Clouds
(Ci. CiS).
O N D J F M A M J J A S
Intermediate Clouds.
(CiC, AS, AC).
O N D J F (M) A M J J A S
W
E
Lower Clouds.
O N D J F M A M J J A S
Wind.
(J)
S
S

From **Norway** and the **North Atlantic Ocean** we have only the observations made at **Bergen** (60° 24′ N. lat.) by M. H. Nielsen, which extend over two years (with the exception of July and August), and the observations made at a number of other stations during the "cloud year" 1896-97.

The results for Bergen are given in Table 21 and on Plate 19, *h*.

TABLE XXI.—Bergen, Norway.

Month.	Cirrus.	Month.	Cirrus.
January	W. 5° N.	July	...
February	W. 46 S.	August	...
March	W.	September	W. 56° S.
April	W. 66 S.	October	W. 38 S.
May	W. 23 S.	November	W. 30 S.
June	W. 25 S.	December	W. 40 S.

The following Table contains the observations made at the remaining stations during 1896-97 :—

TABLE XXII.—Norway, Iceland, etc.

	April to September.			October to March.		
	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.
Lödingen	W. 63° S.	W. 75° S.	W. 54 S.	W. 51° S.	W. 60° S.	W. 49° S.
Drontheim	W. 25 S.	W. 46 S.	W. 28 S.	W. 2 N.	W. 9 S.	W. 2 S.
Aasnes	W. 18 S.	W. 15 S.	W. 80 S.	W. 32 N.	W. 24 S.	E. 53 S.
Christiania	W. 9 S.	W. 9 S.	E. 71 S.	W. 30 N.	W. 29 S.	E. 43 S.
Thorshavn	W. 55 S.	E. 25 S.	W. 25 S.	W. 20 S.	W. 70 S.	W. 26 S.
Reykjavig	E. 70 N.	W. 80 S.	E. 57 S.	E. 50 N.	E. 60 S.	S.
Stykkisholm	W. 3 N.	...	W. 81 S.	W. 43 N.	...	W. 76 S.
Teigarhorni	W. 29 N.	...	W. 3 S.	W. 70 N.	...	W. 23 S.
Upernivik	W. 86 N.	...	W. 59 S.	E. 2 S.	...	E. 46 N.

The geographical co-ordinates of these stations are as follows :—

TABLE XXIII.—Norway.

Lödingen	68° 24′ N. lat.	16° 1′ E. long.
Drontheim	63 26 ,,	10 22 E. ,,
Aasnes	60 37 ,,	11 58 E. ,,
Christiania	59 55 ,,	10 43 E. ,,
Thorshavn	62 2·5 ,,	6 45 W. ,,
Reykjavig	64 9 ,,	21 55 W. ,,
Stykkisholm	65 5 ,,	22 46 W. ,,
Teigarhorni	64 40 ,,	14 19 W. ,,
Upernivik	72 47 ,,	56 7 W. ,,

At **Bossekop** (69° 56′ N. lat., 8° E. long.), a Norwegian station at which measurements of the heights and velocities of clouds were made in 1896-97, the following mean directions at different altitudes were found :—

TABLE XXIV.—Bossekop.

Altitude. Metres.	Feet.	Direction.
0 – 1,000	0 – 3,300	W. 23° N.
1000 – 3,000	3,300 – 10,000	W. 12 S.
3000 – 5,000	10,000 – 16,000	W. 12 S.
5000 – 7,000	16,000 – 23,000	W. 12 S.
7000 – 10,000	23,000 – 33,000	W. 9 S.
above 10,000	above 33,000	W. 13 N.

It should be noticed that the component from the North, which is so marked in Denmark and Sweden during the winter, is also shown at Christiania

and Aasnes, on the eastern side of the Scandinavian highlands, and it can even be traced at Bossekop and Bergen, but it has entirely disappeared at Lödingen, on the island of Hindö, and at Thorshavn in the Faroes. It is again met with at Stykkisholm and Teigarhorni in Iceland.

It should further be noticed that in winter the direction of the upper currents is from the North-east at Reykjavig, a station situated on the southern side of Iceland, on the northern edge of the depressions which pass to the south of the island at this season of the year. In a similar manner the upper wind during the winter months is from the East at Upernivik, on the northern boundary of the large low-pressure system covering Baffin's Bay. This seems to show that in winter depressions over the part of the Ocean lying between Baffin's Bay and the coast of Norway are very strongly developed, and that they extend to a sufficient height to draw the air at the cirrus cloud-level into their rotatory movement. Clement Ley and myself showed that this occurs frequently, but by no means always, in Sweden and in England, while Messrs. Vestin, Åkerblom, Teisserenc de Bort, and others have ascertained that rotating storms over the continent of Europe, as a rule, only attain this height on their southern sides. They are "open towards the north," as M. Teisserenc de Bort has expressed it, *i.e.* their isobars, which form closed curves at the surface of the earth, no longer do so above a certain height, but merely show sinuosities similar to those characterised by squalls and thunderstorms at the surface of the earth.

Observations carried out during the "Polar" year August 1882 to August 1883 at **Jan Mayen** (71° N. lat.) by M. A. Sobieczky, and at **Cape Thordsen** in **Spitzbergen** (78° 28′·5 N. lat.) by M. N. Ekholm have yielded the following results :—

	October to March.	April to September.
Jan Mayen	W. 23° N.	W. 38° S.
Cape Thordsen	W. 55 N.	W. 7 S.

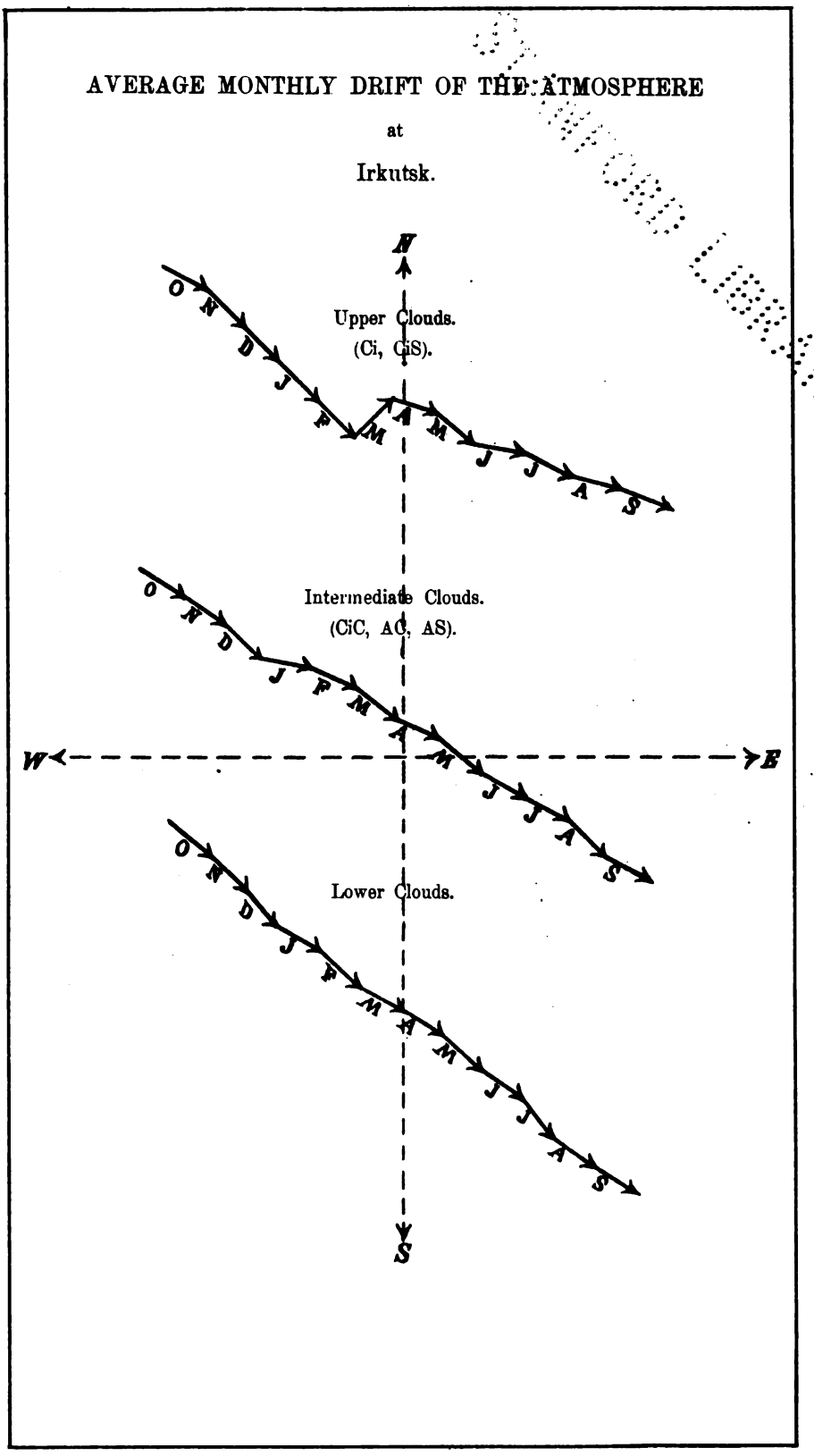
At the most northerly station from which we have records, viz. **Treuremberg Bay** in Spitzbergen (79° 57′ N. lat.), M. J. Westman, working from July 1899 to August 1900, found—

	October to March.	April to September.
Upper Clouds	W. 2° N.	W. 75° S.
Intermediate Clouds	W. 30 S.	W. 72 S.
Lower Clouds	W. 6 S.	W. 48 S.

Tomsk and **Irkutsk**.—M. Rykatcheff has sent me the following results from these two Siberian stations, calculated from the observations of the year 1897 (see also Plates 20 and 21) :—

TABLE XXV.—Tomsk (56° 30′ N. lat., 84° 30′ E. long.), Siberia.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Wind.
January	W. 42° N.	W. 28° N.	W. 5° S.	W. 32° S.
February	W. 50 S.	W. 23 S.	W. 14 S.	W. 85 S.
March	W. 34 S.	E. 24 S. (?)	W. 48 S.	E. 52 S.
April	W. 13 N.	W. 3 S.	W. 13 S.	W. 59 S.
May	W. 73 N.	W. 16 N.	W. 39 N.	W. 3 S.
June	W. 37 S.	W. 8 N.	W. 22 S.	W. 49 S.
July	W. 20 S.	W. 19 S.	W. 54 S.	E. 24 S.
August	W. 22 S.	W. 15 S.	W. 28 S.	W. 66 S.
September	W. 4 S.	W. 13 S.	W. 7 S.	W. 52 S.
October	W. 2 S.	W. 9 S.	W. 21 S.	W. 59 S.
November	E. 79 S.	W. 45 S.	W. 35 S.	W. 72 S.
December	W. 19 S.	W. 19 N.	W. 14 S.	W. 62 S.


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Irkutsk.
N
Upper Clouds.
(Ci, CiS).
O N D J F M A M J J A S
Intermediate Clouds.
(CiC, AC, AS).
O N D J F M A M J J A S
W
E
Lower Clouds.
O N D J F M A M J J A S
S

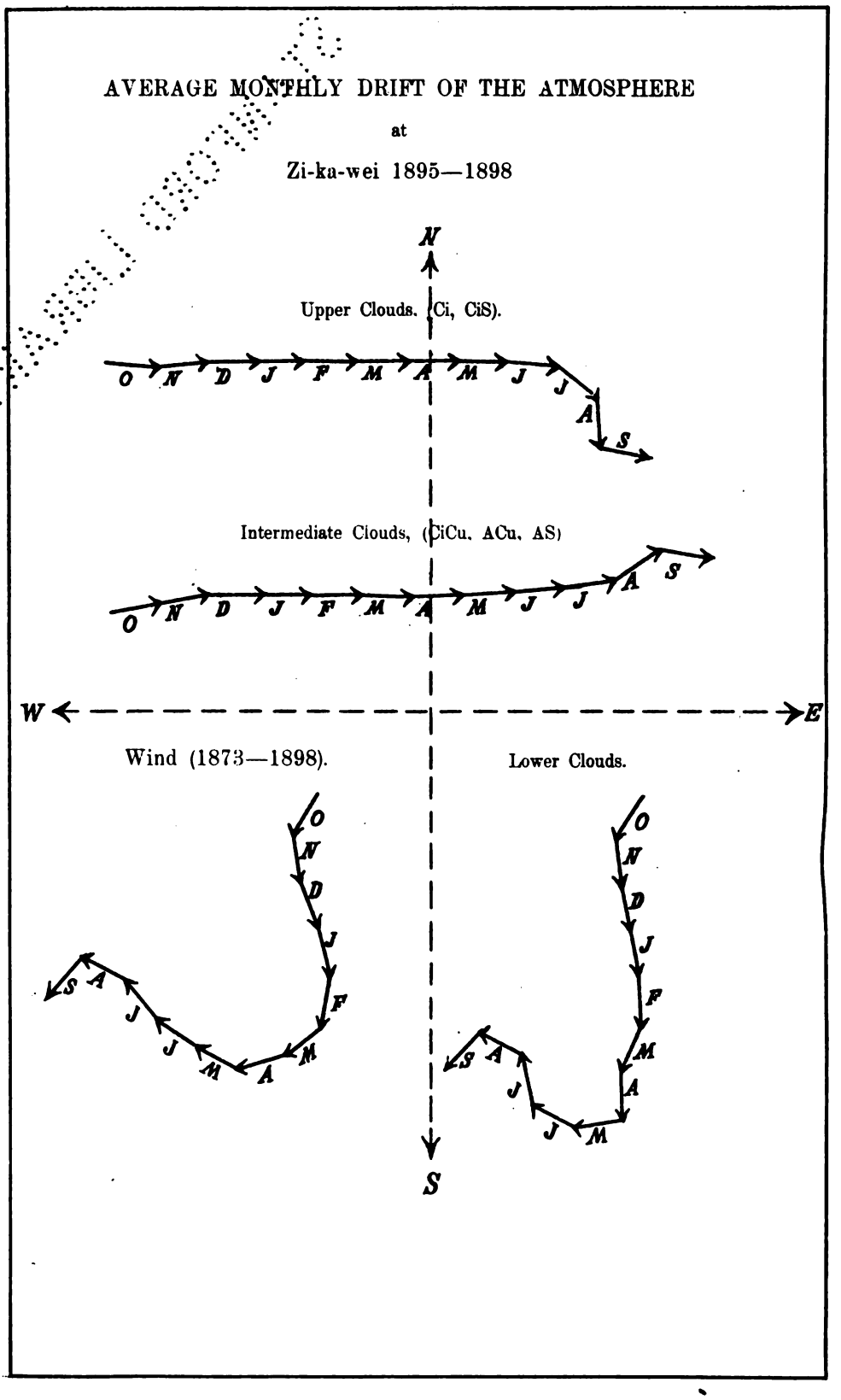

AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Zi-ka-wei 1895—1898
N
Upper Clouds. (Ci, CiS).
O N D J F M A M J J A S
Intermediate Clouds, (CiCu. ACu. AS)
O N D J F M A M J J A S
W
E
Wind (1873—1898).
Lower Clouds.
O N D J F M A M J J A S
O N D J F M A M J J A S
S

TABLE XXVI.—IRKUTSK (52° 16′ N. lat., 104° 19′ E. long.), SIBERIA.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Wind.
January	W. 45° N.	W. 7° N.	W. 29° N.	W. 5° N.
February	W. 45 N.	W. 24 N.	W. 45 N.	E. 36 S.
March	W. 45 N.	W. 32 N.	W. 28 N.	E. 78 N.
April	W. 16 N.	W. 14 N.	W. 32 N.	E. 33 S.
May	W. 40 N.	W. 41 N.	W. 45 N.	W. 23 N.
June	W. 11 N.	W. 27 N.	W. 33 N.	E. 80 S.
July	W. 27 N.	W. 27 N.	W. 53 N.	W. 65 S.
August	W. 13 N.	W. 45 N.	W. 34 N.	W. 24 S.
September	W. 22 N.	W. 27 N.	W. 28 N.	W. 14 N.
October	W. 27 N.	W. 34 N.	W. 39 N.	W. 34 N.
November	W. 45 N.	W. 34 N.	W. 42 N.	W. 41 N.
December	W. 45 N.	W. 45 N.	W. 51 N.	W. 69 N.

These results have been calculated from observations extending over only one year, and they consequently show great irregularities, nevertheless they prove incontestably that the upper currents over Siberia are, generally speaking, from the West at all seasons of the year.

From the Far East, China and Japan, some excellent observations are available.

Zi-ka-wei (31° 11′·5 N. lat.).—As has already been stated, the Rev. Father Marc Dechevrens, the director of the Observatory at Zi-ka-wei, was the first to point out that the *mean* direction of motion of cirrus cloud bears no relation to the *mean* atmospheric pressure at the surface of the ground. He found that the upper currents of the atmosphere in Eastern Asia always move from the West at all seasons of the year, in spite of the high and low barometric pressures which prevail in winter and summer respectively.

The international classification of clouds has been adopted at Zi-ka-wei Observatory since 1895, and the average drift of clouds has been calculated for the years 1895-98 with the following results (see also Plate 22) :—

TABLE XXVII.—ZI-KA-WEI, CHINA.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.	Wind.
January	W. 3° S.	W. 1° N.	W. 82° N.	W. 79° N.
February	W.	W. 1 S.	W. 88 N.	E. 78 N.
March	W. 2 N.	W. 5 N.	E. 64 N.	E. 37 N.
April	W.	W. 2 S.	W. 88 N.	E. 15 N.
May	W.	W. 6 S.	E. 10 N.	E. 33 N.
June	W. 5 N.	W. 6 S.	E. 24 S.	E. 36 S.
July	W. 43 N.	W. 10 S.	E. 80 S.	E. 52 S.
August	N.	W. 34 S.	E. 27 S.	E. 27 S.
September	W. 9 N.	W. 6 S.	E. 46 N.	E. 43 N.
October	W. 5 N.	W. 8 S.	E. 56 N.	E. 59 N.
November	W. 7 N.	W. 18 S.	E. 73 N.	W. 83 N.
December	W.	W.	W. 78 N.	W. 64 N.

From the *Annual Report of the Central Meteorological Observatory of Japan*, I have abstracted the following summaries of the average motion of upper clouds and the direction of the wind at **Hiroshima** (34° 23′ N. lat.) and **Hakodate** (41° 46′ N. lat.) for the five years 1894-1898 (see also Plates 23 and 24).

TABLE XXVIII.—JAPAN.

Month.	Hiroshima. Cirrus.	Hiroshima. Wind.	Hakodate. Cirrus.	Hakodate. Wind.
January	W. 1° N.	E. 84° N.	W. 2° S.	W. 44° N.
February	W. 5 N.	E. 87 N.	W. 17 N.	W. 52 N.
March	W. 2 N.	E. 86 N.	W. 17 N.	W. 43 N.
April	W. 10 N.	W. 83 N.	W.	W. 32 N.
May	W. 7 S.	W. 55 N.	W. 6 N.	W. 79 S.
June	W. 3 S.	W. 15 N.	W. 6 N.	E. 82 S.
July	W. 5 S.	W. 25 S.	W. 14 N.	E. 64 S.
August	W. 11 S.	W. 2 S.	W. 21 N.	E. 38 S.
September	W. 11 S.	E. 74 N.	W. 6 N.	E. 74 N.
October	W. 10 S.	E. 71 N.	W. 2 S.	W. 49 N.
November	W. 1 N.	E. 77 N.	W. 6 N.	W. 38 N.
December	W. 7 S.	E. 88 N.	W. 14 N.	W. 36 N.

The direction of the upper currents in the Far East is thus from the West throughout the year. At Zi-ka-wei this is also true of the intermediate clouds. The monsoons, which are the determining factors in the climate of these regions, are seen to be currents of slight depth scarcely exceeding 10,000 to 13,000 feet (3000-4000 metres). This fact is borne out by the isobaric charts for the 4000 metres (13,000 feet) level prepared by Teisserenc de Bort (see above, Plate 6).

From the temperate zone of the southern hemisphere we have only two sets of observations, and these are incomplete. From some old observations of M. Neumayer I have calculated the average direction of cirrus at **Melbourne** as from W. 16° N., and 95 observations made at **Mercedes** (Uruguay) by M. Tanini give W. 9° N.

The observations quoted above establish the fact that the greater portion of the mass of air above the temperate zones up to the height of cirrus clouds, 26,000-36,000 feet (8000-11,000 metres), is in general endowed with a drift from West to East. Except for the lowest layers, more especially in the region of the monsoons, the whole mass of air in both hemispheres is involved in huge whirlpools of which the centres lie at or near the poles. Exactly as in ordinary cyclones, the lower layers approach spirally towards the centre, while the upper ones recede from it, the component from the North becoming more and more marked the nearer we approach the level of cirrus clouds.

In the regions above this level there are no clouds. M. Teisserenc de Bort has, however, communicated to me the following facts concerning the direction of motion of a number of unmanned balloons which rose considerably above the level of cirrus clouds. "The drift of the air above the cirri," he says in a letter, "is towards a more southerly point than that of the cirri themselves. For example :—

"*March* 9, 1901.—Wind South-west; cirri from W. 35° S. A balloon, liberated at Trappes, came to earth at a point E. 20° S. of Trappes. It must therefore have met with winds from the North-west above the cirri.

"*May* 12, 1901.—Winds from North-west and West. Balloon fell in the south. It must therefore have met with a Northerly current above.

"*June* 20, 1901.—Wind East-south-east; alto-cumulus E. 40° N. Balloon fell E. 80° S.; it must therefore have met with upper winds from North-west.

"*April* 28 1900.—Wind North-east; cirrus E. 60° S. Balloon fell N. 30° E.

"*June* 16, 1900.—Wind West; Cirrus West. Balloon fell S.E.

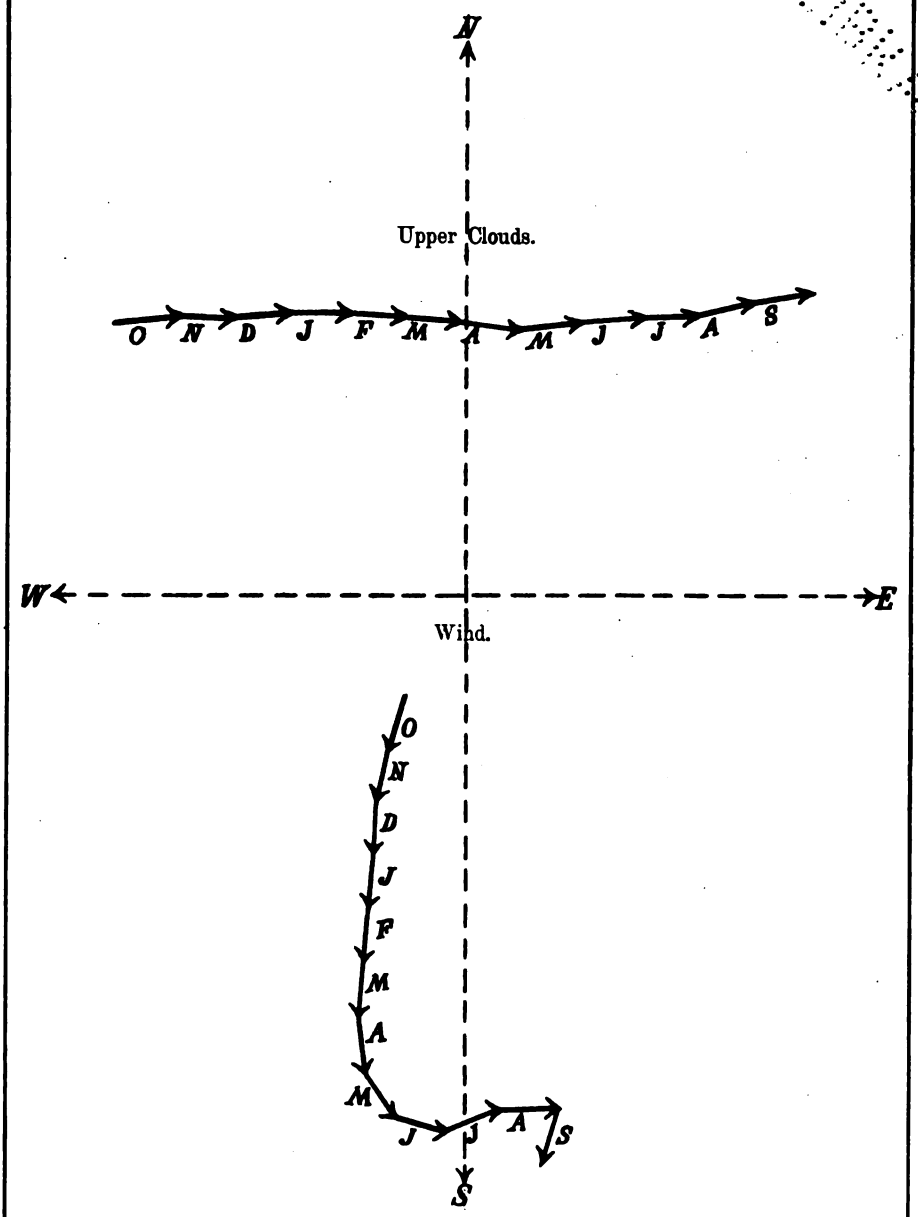
"You will see from these examples that the balloons always came to earth on the right-hand side of the path of the cirrus clouds, and very much to the right of the mean direction of motion of the lower layers of the atmosphere."

The upper atmosphere, up to the greatest altitudes which we have as yet succeeded

AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

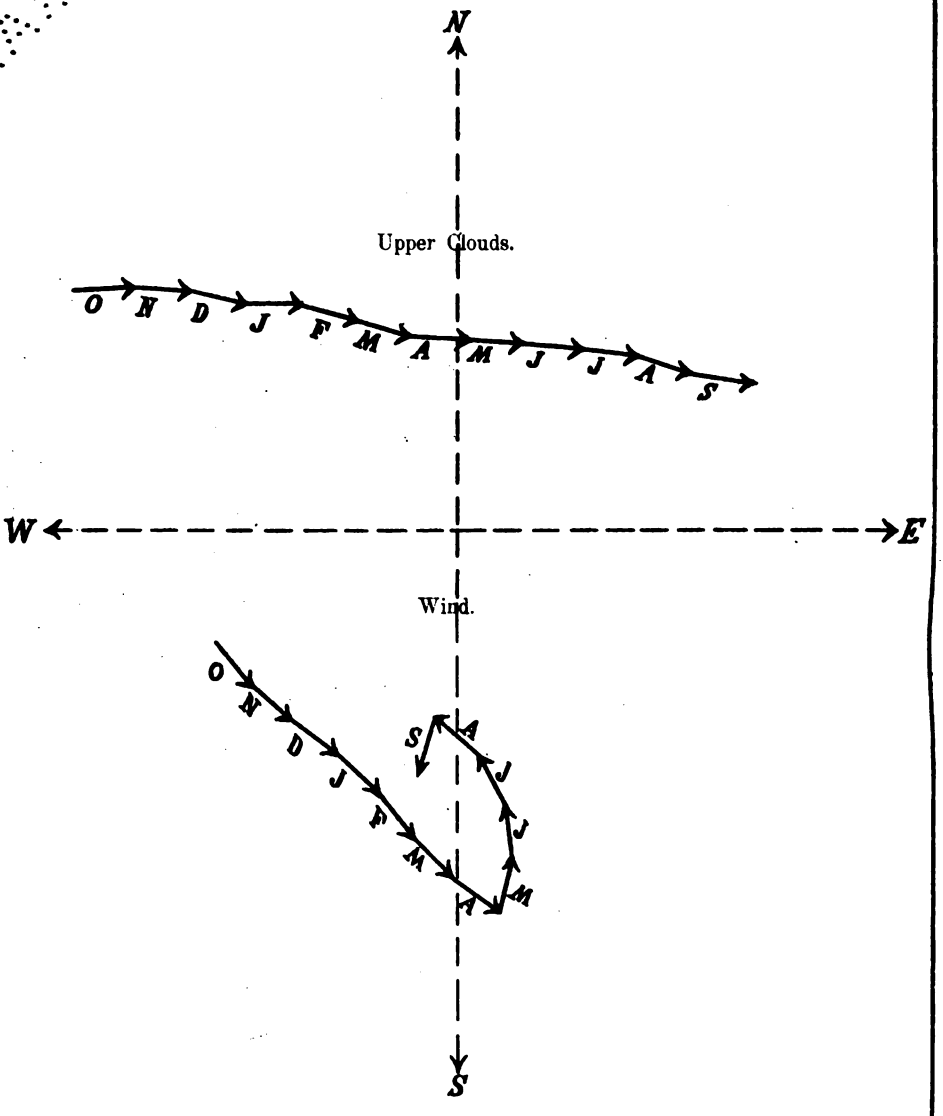
Hiroshima (Japan) 1894—1898.



AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

Hakodate (Japan).



in reaching, has a West to East motion, with a component from the North which increases with the altitude.

From this it follows that the upper currents from the South shown in the schemes by Ferrel and James Thomson have no existence below a level of 10-12 miles (15-18 kilometres), and the *mass* of air above this level is very small.[1] *The idea of a vertical circulation between the tropics and the poles must therefore be abandoned once for all;* such a circulation seems moreover to be hardly possible in practice in a layer of which the thickness is very small compared with its horizontal extent. Let us hope that these "polar" and "equatorial" currents which have been the cause of so much confusion in dynamical meteorology in the past will disappear entirely from meteorological science, at any rate in the sense in which they have been understood hitherto.

V.—SUBTROPICAL ZONE.

Hitherto it has been generally assumed that the anti-trade winds extend over the high-pressure regions at the tropics, and that they continue their course towards the poles as "equatorial" currents either at the surface of the earth (Dove, Maury) or as upper currents (J. Thomson, Ferrel). We have, however, now ascertained the following facts:—(1) the anti-trade wind, by the time it reaches the northern limit of the trade wind in the neighbourhood of the ridge of the tropical high-pressure area, has been so much deviated to the right that it has become a wind from the West; and (2) the air above the temperate zone is involved in a vast whirlpool which revolves from West to East, and of which the centre is in the polar regions where the pressure is lowest. In the lower layers of this whirlpool, the air is approaching the centre, and in the upper layers it is receding from it in exactly the same way as in ordinary cyclones. This being so we should expect the upper currents as they leave this whirlpool to encroach on the northern slopes of the tropical high-pressure region which would thus be fed from both sides; by the anti-trade wind from the South, and by a current from the North-west or the North. This is precisely what actually occurs as the following observations show. From Europe we have observations from **Perpignan, Pola, Tiflis** (Caucasus) and **Madrid.** (Tables 29 and 30, and Plates 25 and 26.)

TABLE XXIX.[2]—PERPIGNAN.

Month.	Upper Clouds.	Intermediate Clouds.	Lower Clouds.
January	W. 34° N.	W. 37° N.	W. 52° N.
February	W. 39 N.	W. 33 N.	W. 36 N.
March	W. 32 N.	W. 33 N.	W. 24 N.
April	W. 31 N.	W. 40 N.	W. 30 N.
May	W. 28 N.	W. 28 N.	W. 18 N.
June	W. 18 N.	W. 13 N.	W. 10 N.
July	W. 17 N.	W. 22 N.	W. 27 N.
August	W. 23 N.	W. 14 N.	W. 18 N.
September	W. 11 N.	W. 17 N.	W. 12 N.
October	W. 15 N.	W. 4 N.	W. 14 N.
November	W. 34 N.	W. 29 N.	W. 26 N.
December	W. 27 N.	W. 33 N.	W. 32 N.

[1] M. Teisserenc de Bort has found that the decrease of temperature diminishes at very great altitudes, and attempts have been made to explain this phenomenon by assuming that the balloons had reached the upper equatorial current. But on the one hand the upper currents have, as we have just seen, a large northerly component, and on the other hand the inversion of temperature is different over low-pressure areas to what it is over high-pressure areas. The explanation of the increase of temperature must therefore probably be sought in dynamical causes.

[2] Fines, *Bulletin météorologique des Pyrénées Orientales.*

TABLE XXX.[1]

Month.	Pola, 44° 53′ N. Lat. Cirrus.	Tiflis, 41° 22′ N. Lat. Cirrus.	Madrid, 40° 25′ N. Lat. Cirrus.
January	W. 77° N.	W. 50° N.	W. 46° N.
February	W. 25 N.	W. 70 N.	W. 22 N.
March	W. 25 N.	W. 55 N.	W. 44 N.
April	W. 27 N.	W. 25 N.	W. 20 N.
May	W. 12 N.	E. 80 S. (?)	W. 6 S.
June	W. 25 N.	W. 28 N.	W. 23 S.
July	W. 12 N.	W. 65 N.	W. 32 N.
August	W. 20 N.	E. 35 S. (?)	W.
September	W. 10 N.	W. 21 S.	W. 1 N.
October	W. 8 N.	W. 22 S.	W. 37 N.
November	W. 3 N.	W. 50 N.	W. 36 N.
December	W. 10 N.	W. 48 N.	W. 35 N.

According to Dallas[2] the direction of motion of cirrus in the **Gulf of Persia** is from North-west at all seasons of the year.

During the "cloud year" the following mean directions for various altitudes were found at **Washington**[3] (38° 53′ N. lat.).

TABLE XXXI.—WASHINGTON.

Feet.	Metres.	April to September.	October to March.
below 3,300	below 1,000	N. 42° W.	S. 71° W.
3,300 - 10,000	1000 - 3,000	N. 66 W.	N. 87 W.
10,000 - 16,500	3000 - 5,000	N. 84 W.	S. 79 W.
16,500 - 23,000	5000 - 7,000	N. 89 W.	S. 80 W.
23,000 - 33,000	7000 - 10,000	N. 80 W.	N.
above 33,000	above 10,000	N. 77 W.	N. 79 W.

We have already seen that the upper winds from the North-west extend in the autumn as far south as Cuba.

SUMMARY

The following results have been established by direct observation :—

1. Above the thermal equator and the equatorial calms there exists throughout the whole year a current from the East which appears to have a very high velocity at great altitudes.

2. Above the trade winds anti-trade winds, from South-west in the northern hemisphere and from North-west in the southern hemisphere, prevail.

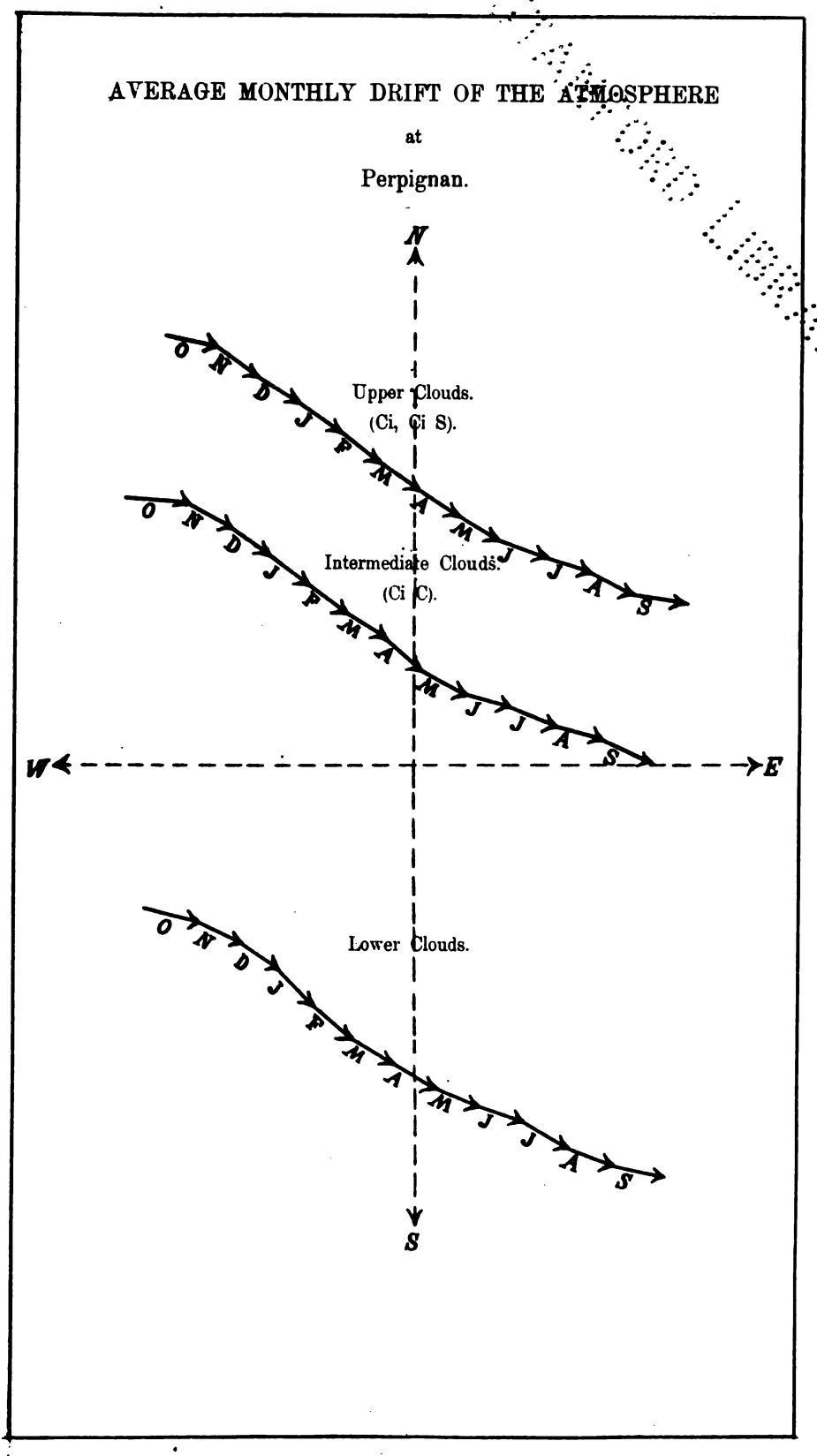
3. These anti-trade winds do not extend beyond the polar limits of the trade winds ; they are deviated to the right in the northern hemisphere and to the left in the southern hemisphere and become a current from the West above the ridge of the tropical high-pressure areas, where they descend to feed the trade winds.

4. The average pressure of the atmosphere continually diminishes from the tropical high pressure-areas to the poles or at any rate to the polar circles. Thus the air of the temperate zones is involved in a vast "polar whirlpool," which rotates from West to East. This rotatory movement appears to be similar to that of an ordinary cyclone : the air in the lower layers draws nearer to the centre while that in the upper layers recedes from it more and more as

[1] MS. observations communicated by MM. J. Palisa, H. Kiefer, and A. Aguilar.

[2] Upper currents of air over the Arabian Sea, *Quart. Journ. Roy. Met. Soc.*, vol. 19, 1893, p. 239.

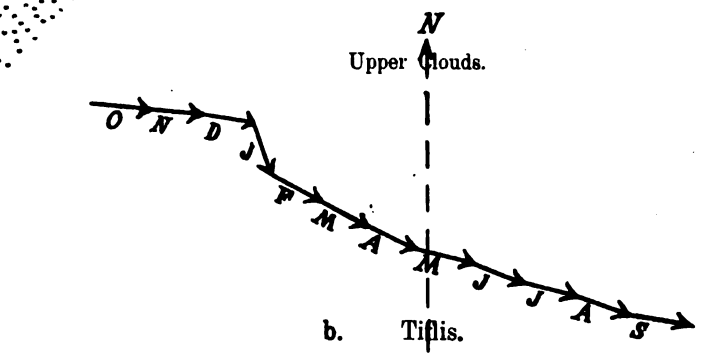
[3] Frank H. Bigelow, *Report on the International Cloud Observations*, May 1, 1896, to July 1, 1897.


AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE
at
Perpignan.
N
O N D J F M A M J J A S
Upper Clouds.
(Ci, Ci S).
O N D J F M A M J J A S
Intermediate Clouds.
(Ci C).
W
E
S
O N D J F M A M J J A S
Lower Clouds.

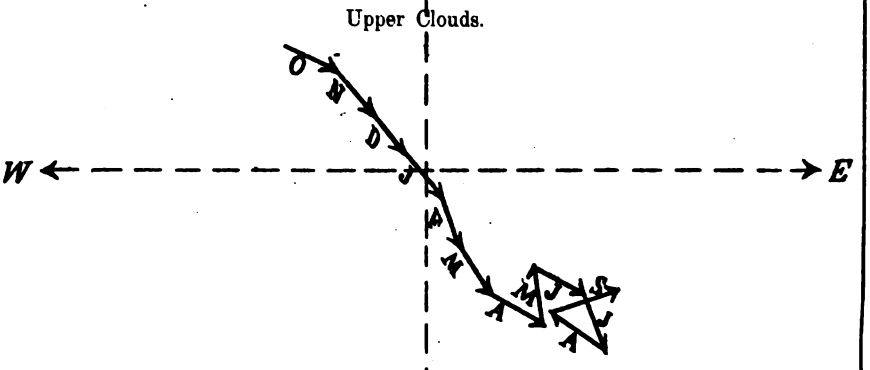
AVERAGE MONTHLY DRIFT OF THE ATMOSPHERE

at

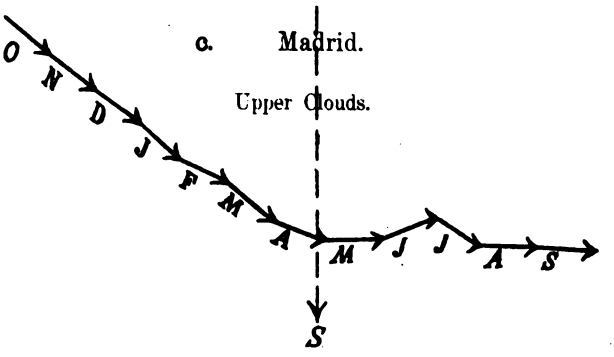
a. Pola (Austria).



b. Tiflis.



c. Madrid.



the height above the surface of the earth increases, up to the highest regions from which we have any observations.

5. The layers of upper air over the temperate regions extend over the tropical high-pressure areas and there descend.

6. The irregularities found at the surface of the earth, more particularly in the monsoon areas of India, disappear as a general rule at a lower altitude than that of the lower or intermediate clouds.

7. The theory of a vertical circulation between the tropics and the poles, which has hitherto been accepted (Ferrel, and James Thomson), must be finally abandoned.

The causes of the general circulation of the atmosphere described above which is so much simpler than those hitherto assumed, cannot be discussed here. It should, however, be noticed that Dunér's[1] spectroscopic researches have shown that an analogous circulation is taking place in the sun, but the direction of the currents is reversed. He has established the fact that the rotation of the sun is not the same for all latitudes, the rate of revolution being greatest at the equator and diminishing towards the poles. This proves that there must be a current from West to East at the equator and large polar whirlpools revolving from East to West on either side of this central current.

The results, which have been arrived at, have been deduced directly from the observations and all theories or hypotheses have been carefully avoided.

It should also be noticed that the direction of the upper currents appears to agree very closely with the mean path of the centres of barometric depressions. It therefore seems probable that barometric depressions, or at any rate a large number of them, arise as secondary effects of the grand currents of the atmosphere. Indeed, if part of any current has a greater velocity than the masses of air in front of it, the excess of energy is converted into a rotatory movement, just as if the faster moving air had met with an obstacle. It has also been noticed that the velocity of the upper currents is frequently greater in the rear of a disturbance than in front of it. These important questions will be returned to on a future occasion.

[1] N. C. Dunér: Recherches sur la rotation du soleil," *Act. Soc. Reg. Sc.*, Upsal., 1891.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 18, 1904.

Ordinary Meeting.

Capt. D. Wilson-Barker, F.R.S.E., President, in the Chair.

Walter Moorcroft Edwards, Krugersdorp;
Edward George Fenning, 5 Briarwood Road, Clapham;
Knightley H. Maule Ffinch, Singapore, Straits Settlements;
Reginald Guy Kirkby, Pietersmaritzburg, Natal; and
Leon George Harold Lee, Raunds, Wellingborough,
were balloted for and duly elected Fellows of the Society.

The discussion was taken on Mr. W. L. Dallas's paper, "The Variation of the Population of India compared with the Variation of Rainfall in the Decennium 1891-1901" (p. 273), which had been postponed from the last Meeting, after which the following communications were read:—

(1) "THE PRINCIPAL CAUSES OF RAIN." By the Hon. F. A. ROLLO RUSSELL, F.R.Met.Soc. (p. 287).

(2) "MONTHLY RAINFALL AT THE ROYAL OBSERVATORY, GREENWICH, 1815-1903." By WILLIAM C. NASH (p. 291).

June 15, 1904.

Ordinary Meeting.

Capt. D. WILSON-BARKER, F.R.S.E., President, in the Chair.

FREDERICK W. FITZSIMONS, F.Z.S., Pietermaritzburg, Natal; and
GEORGE WILLIAM BERNINI PALMER, Princetown, Devon,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

(1) "EFFECTS OF A LIGHTNING STROKE AT EARL'S FEE, BOWERS GIFFORD, ESSEX, APRIL 13, 1904." By the Rev. C. F. BOX (p. 307).

(2) "AN INSTRUMENT FOR DETERMINING THE TRUE DIRECTION AND VELOCITY OF THE WIND AT SEA." By A. LAWRENCE ROTCH, M.A., F.R.Met.Soc. (p. 313).

CORRESPONDENCE AND NOTES.

Meteorological Observations at Engstlen Alp, Switzerland, August 1904.—Engstlen Alp is situated 6033 ft. above sea-level, on the route from Meiringen to Engelberg over the Joch Pass, and just at the point where the path from the Gent-thal turns eastward towards the Pass. The exposure is open to the south-west, but somewhat confined by comparison on the other sides. The trend of the valley being south-west to north-east the valley is open to the rain-bearing wind.

The weather after the early part of August was unsettled, following upon a long fine and dry spell. Thus on the 10th and 11th thunderstorms occurred in the afternoons with heavy rain, and there was much lightning on many evenings. A glance at the cloud column in the accompanying Table will show that there was no spell of clear weather.

A sharp fall of temperature from the 18th to 19th will be observed from the Table.

On the 21st occurred a heavy thunderstorm between 7.30 and 8.30 p.m., and fresh snow fell on the hills above the station the next day.

Another sharp fall of temperature will be observed between the 21st and 23rd. On the morning of the 23rd more than 3 ins. of snow lay about the station, but there was none on the ground below 4850 ft. By evening of that day on the Pass (7265 ft.) the snow was about 10 ins. deep, and 3 to 4 ft. deep in the drifts. Snow continued alternately with rain and sleet until the morning of the 26th, when the weather cleared and became very fine for a few days. Rain, however, set in again on the 31st, and there was snow on September 1 and 2, more than 4 ins. lying on the Joch Pass on the latter day.

The phenomena of up-valley wind in the day time and of down-valley wind in the night time were marked, especially the former. The down-valley wind generally occurred under a clear sky, and would doubtless have been more often observed farther from the head of the valley. It began about 8 p.m., but sometimes earlier, and occasionally lasted later than 8 a.m.

There was a considerable difference in the levels at which cumulus clouds formed on mornings beginning with clear skies, *e.g.* on the 19th the level was much lower (wind S.S.W.) than on 17th (wind N.E.), and on the 20th (wind S.S.W.) the level was about that of the 19th.

The following instrumental and other observations may be of interest:—

1904.	Barometer.		Thermometers.						Wind Direction.		Cloud (0–10).	
	8 a.m.	7 p.m.	8 a.m.		7 p.m.		Max.	Min.	8 a.m.	7 p. m.	8a.m.	7p.m.
			Dry.	Wet.	Dry.	Wet.						
Aug.	ins.	ins.	°	°	°	°	°	°				
11	24·15	24·10	...	...	...	...	...	...	S.W.	S.W.	1	9
12	24·20	24·25	54·8[1]	...	53·4	...	64·0	...	S.W.	W.S.W.	10	9
13	24·30	24·28	52·8	...	55·8	...	66·8	49·0	S.W.	S.W.	1	3
14	24·31	24·28	56·8	53·1	58·4	54·8	69·2	48·1	W.S.W.	W.	8	1
15	24·26	24·21	62·2	57·2	60·4	56·3	71·0	48·8	S.W.	S.W.	9	7
16	24·23	24·20	56·0	55·1	57·8	56·4	69·8	51·2	S.W.	W.S.W.	9	8
17	24·20	24·10	58·0	54·1	59·3	56·8	68·9	46·1	N.E.	N.E.	0	1
18	24·03	24·06	55·1	51·8	48·6	47·6	64·0	50·0	S.S.W.	W.	10	7
19	24·07	24·09	44·8	42·9	50·8	49·8	59·0	35·0	Calm	S.S.W.	0	6
20	24·08	24·09	49·6	46·6	54·0	52·4	63·8	38·4	Calm	S.S.W.	1	8
21	24·08	24·02	58·3	53·0	55·9	53·8	67·0	45·6	E.	S.W.	9	10
22	23·94	23·93	48·6	47·4	42·7	42·7	52·9	45·1	S.S.W.	W.S.W.	10	10
23	23·85	24·01	36·6	35·9	35·2	34·8	44·3	32·0	Calm	N.W.	10	10
24	23·93	23·90	40·7	39·8	39·4	39·0	55·6	34·7	W.N.W.	Calm	10	10
25	23·90	24·01	36·8	36·2	34·7	34·7	47·0	34·6	N.W.	N.	10	10
26	24·12	24·16	38·8	38·0	38·2	37·6	54·4	33·1	N.N.E.	W.N.W.	9	2
27	24·20	24·20	44·0	40·0	49·6	47·9	60·0	32·0	N.	W.	2	9
28	24·19	24·19	47·8	44·0	52·8	51·1	63·7	38·7	N.	Calm	0	1
29	24·18	24·15	51·9	46·7	51·6	50·5	63·8	40·0	N.	N.	0	1
30	24·11	24·06	54·1	48·6	54·8	51·7	68·6	43·8	N.	N.	1	7
31	24·01	24·02	49·6	48·6	49·4	48·9	56·0	46·3	S.	S.W.	10	9
Sept.												
1	24·02	24·07	43·7	43·1	40·6	39·7	52·0	38·2	Calm	W.S.W.	10	10
2	24·06	...	39·6	38·5	...	...	...	34·8	N.	...	9	...

[1] 10 a.m.

The barometric observations were taken with a small aneroid and are not corrected for altitude, the temperature readings with thermometers duly verified at Kew Observatory.—F. DRUCE.

Meteorology of the Swedish Antarctic Expedition.—Dr. Nordenskiöld contributes a summary of the scientific results of the Swedish Antarctic Expedition in the *Geographical Journal* for February. The following is a summary of the meteorological work of the expedition.

The place selected for the winter station of the expedition was at the foot of Snow Hill, in Admiralty Inlet, on February 12, 1902. Observations were started as soon as possible under the direction of Dr. Bodman, who was the meteorologist and magnetician of the expedition. The observations were carried on without interruption until November 8, 1903, when the members of the expedition at the winter station were taken off by the Argentine Relief Expedition. It may be recalled that the expedition lost their ship, *The Antarctic*, about 20 miles south from Dundee Island, the ship being crushed by ice-pressure, caused by a violent gale on January 10, and finally abandoned on February 12, the crew making their way with great difficulty to Paulet Island.

Meteorological observations were laid down as one of the most important sections of the work of the expedition, and the results will be fully discussed by Dr. Bodman in due course.

The following table, however, gives the approximate monthly means of temperature, and barometric pressure :—

Month.	Temperature.		Barometer	
	1902.	1903.	1902.	1903
	°	°	ins.	ins.
January . . .	...	30·4	...	29·28
February . . .	...	25·7	...	29·05
March . . .	14·9	11·5	29·25	28·96
April	7·9	6·4	29·31	29·07
May	1·4	−2·9	29·12	29·18
June	−0·6	−6·3	29·34	29·13
July	−11·9	0·9	29·29	28·95
August . . .	−8·5	2·5	28·96	29·12
September . . .	6·3	1·2	29·10	29·18
October . . .	9·1	20·5	28·99	29·02
November . . .	17·4	...	29·28	...
December . . .	28·4	...	29·26	...

The minimum temperature recorded was −42°·2 in August 1902, the maximum for the same month being 48°·7.

Dr. Nordenskiöld makes the following remarks :—"According to approximate calculations of our astronomical observations, the situation of the winter station was in 64° 22′ S. and 57° 0′ W. The nearest places where meteorological observations have been carried out during a time of sufficient length are at Cape Horn, and in the region where the *Belgica* wintered, and from the results thus obtained we might have expected to find here a yearly mean of about 20° or 25°. Instead of this we obtained for the first year +10°. Though it is possible that this temperature is somewhat lower than general, as the summer was undoubtedly exceptionally cold, and even the mean for the eight colder months (March-October) was in the first year 2°·3, but in the second 4°, it does not seem probable that the difference from that general mean temperature should be even so great as between the two winters. A mean temperature of 10° at the same distance from the pole is in the northern hemisphere found in the environs of Hudson strait, and in Siberia, in the region of Yakutsk, still one or two degrees farther south. In both cases we see the influence of the extremely low winter temperatures of a continental climate, while for a thoroughly marine climate the temperature is unexpectedly low. It must be left to the discussion of the observations of the other expeditions contemporaneous with ours, including the *Scotia* Expedition, to discover whether there exists an especially cold area on the east coast of Graham Land, or even south of the Atlantic Ocean.

"The difference in temperature between summer and winter is, of course, not so great as in the regions mentioned, and, notwithstanding that the temperature of the three winter months was during the two years as low as −4°, the winter could not be called very cold if it was not for the wind. The great violence of the wind in all Antarctic regions is a well-known fact, but I doubt if a violence such as that during our first winter has ever been experienced in an Arctic or Antarctic climate, and even the average for the whole time must be considered unexpectedly high.

"The factor that really determines the climate is the direction of the wind. The situation of the station, on the shore of a strait, may partially account for the predominance of the winds from the South-west and North-east quadrants. Besides this, there is a high percentage of calm or nearly calm weather. The South-west winds are by far the most common and the strongest, and, because they are also the coldest, all the really bad weather is to be ascribed to them. The calm hours are not much warmer, but of course their influence on the general feeling is absolutely different. The real North-east winds are com-

paratively strong and cold ; but, besides them, there is another class of winds which are, if not as common as the others, still exceedingly characteristic of the climate. They are the winds from North or even North-north-west, and when once started they are very strong and very long-continued, and bring the warmest weather. It is these differences that bring out another characteristic of the climate—its great variability. The variations from day to day are in winter time greater, as in most other regions of the world, and, as far as our short experience goes, it is quite probable that this also holds good from year to year. Though the mean temperature of these two winters is nearly the same, the difference between the two is very great. In the first year the South-west storms were absolutely overwhelming, alternating with periods of calm, warmer weather. In the second year the calm periods were generally colder, and, at least during the first part of the winter, very common and long-continued, and to this cause during the second half were due long periods of warm Northerly winds."

Weather Reports by Wireless Telegrams.—Mr James Glaisher in a letter to Professor Joseph Henry on July 8, 1850, said : "I should be glad to have some arrangements made with the captains of steam-vessels between America and England, thus connecting the observations taken in both countries, and I think this may ultimately be done." [1]

The above paragraph has a special significance, as it has now become possible to receive by Marconigrams information regarding the weather from ships in mid-ocean. As on August 31, 1848, the *Daily News* was the first to publish regular telegraphic Daily Weather Reports, so on August 6, 1904, the *Daily Telegraph* has been the first to publish regular Weather Reports from the Atlantic by Wireless Telegraphy.

We reprint the reports and article in the issue of that date :—

WIRELESS TELEGRAMS.—WEATHER REPORTS FROM THE ATLANTIC.

Message from the 'Tunisian.'

AUGUST 4, Noon.—Lat. 56° N., long. 20° W. ; bar. 29·40 ; therm. 54° ; blue sky, with detached clouds ; wind W., moderate ; sea rough. Midnight.—Lat. 56°, long. 15° W. ; bar. 29·55 ; therm. 59° ; detached clouds, passing showers ; wind W., strong breeze ; high sea.

AUGUST 5, Noon.—Lat. 56° N., long. 9° W. ; bar. 29·70 ; therm. 62° ; overcast, passing showers ; wind W., gentle breeze ; moderate sea.

"The wireless messages from the homeward-bound Allan liner, *Tunisian*, printed above, represent the first step in the development of a system by which we hope to be able to supply the data which the forecaster requires most to know in order to predict the probable weather over the British Islands. They inaugurate, as we have every reason to hope, a system destined to be of the utmost value to the people of the United Kingdom, and ultimately to the whole of Western Europe.

"All our storms and all our calms, the disheartening rains of June and July last year, and the glorious summer so far of the present season, come from the Atlantic, travelling from the west eastward. No matter where the cyclone or anti-cyclone may arise, no matter in what direction a portion of its track may lie, in the long run its course will be Eastward. Not that the winds will be all Westerly. In our hemisphere a depression has Easterly winds to the North and Westerly winds to the South of it, but the depression itself moves towards the rising sun. If you ask the expert meteorologist who sits in his office in Victoria

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. **29**, p. 134.

Street, Westminster, what more he desires in the way of data on which to found his anticipations, he will answer, "Let me know the readings of the barometer, the strength and direction of the wind, the condition of the sea, and the state of the weather 1000 miles to the west of Ireland." The Meteorological Office has twenty-seven chief reporting stations scattered round the coast, but, needless to say, not one out in the broad Atlantic; and it is not going beyond the truth to say that daily messages from mid-ocean would be worth at least as much—we should say confidently worth a great deal more—than all the other reports put together. With the splendid inventions of Mr. Marconi, nearly every liner crossing the Atlantic has become at once an observing station and a telegraphic centre. Two or three ships—British, American, and German—come every day within signalling distance, and they can send us reports of possibly the utmost value. Of such reports we print to-day the first, the pioneers, we are sanguine enough to think, of a service destined to be of incalculable advantage.

"The messages we print above were despatched at a distance of about 70 miles from the mainland. They were received at Malin Head, and thence transmitted by the ordinary postal telegraph lines. It will at once occur to anyone moderately conversant with meteorology that a weather report which originates less than 100 miles away from our extreme stations, cannot be of much service. As a rule, this objection would be valid; one of the storm centres marked on the map printed in another column travelled 600 miles in a single day; but this is by no means the universal rate of speed. On the same map a cyclone is indicated moving less rapidly than a mail steamer. A hundred miles, however, is not the limit to which wireless messages can be sent; it is practically at this moment the limit at which they can be despatched from the steamer to the land; but a message was received a few days ago on board ship 2,250 miles from the transmitting station. In the new Cunarders now building the "Marconi cabin" will be equal to all requirements. The time will certainly come, and that ere long, when messages will reach us from mid-Atlantic, recording precisely what the forecaster wants above all things to know; and, of course, from mid-Atlantic means practically the entire transit from shore to shore.

"But the arrangement we have made with the Marconi Company is that the steamer the moment she comes within signalling distance of Brow Head, in the extreme West of Ireland, Malin Head in the North, or Poldhu, in Cornwall, shall report to us not only the weather conditions at that moment, but also those of the previous day, during which the ship may have run 400 or 500 miles. We shall thus have at least two reports that may be compared with each other, and from their combined indications inferences of the highest significance may be drawn.

"To-morrow's weather depends upon depressions which are now careering somewhere over the North Atlantic. They may be making straight for us, or they may be so far north or south that we shall hardly feel their influence. There is always a centre of depression somewhere; the forecaster in Victoria Street wishes to know where that centre is, how deep it is, which way it is moving, whether it is filling up or deepening, and with this information at hand he can give a shrewd guess, right in ninety cases out of a hundred, when, if at all, the disturbance will strike our coast, and of what sort it is likely to be. It may be a gentle little eddy of no particular consequence, but several times in the course of every year it will be a violent atmospheric whirlpool, with hurricane force of wind and deluges of rain in its track. At present the Meterological Office is excellently manned. Dr. Shaw, F.R.S., and his staff make the utmost use of the data at their command, but the area from which above all others they want information is a blank. What is happening over the Atlantic they can only guess. If our messages had been despatched from a liner making for Queenstown the information would have placed beyond a doubt the con-

jecture which the Meteorological Office published this morning as to the presence of a severe depression south-west of Ireland. It is clear from the *Tunisian's* report that a depression to the north of her had caused rough weather, and that as she came eastward she was passing out of its influence. It is highly probable, therefore, that the storm centre will move to the north-east clear of these islands, and that from that direction at all events we have nothing to fear for the next two days.

"Let us take an historic example of the disabilities imposed on our forecasting system by the short range of its observing stations in the west. One of the fiercest windstorms of modern times was that which broke over these islands on the morning of Oct. 14, 1881. Hundreds of fishermen and others perished at sea, and an enormous amount of property was lost that might, and probably would, have been saved if wireless telegrams from the Atlantic had then been in use. The hurricane was preceded by a smaller one; of this warnings were sent out, and the fishing fleet on the East Coast remained in the harbours. When this lesser disturbance, which was merely a forerunner, had passed, the storm warnings were lowered, and the fishermen put out to sea. They had hardly done so when the tempest coursed over the country, leaving traces of wreck and havoc on sea and land hardly ever paralleled.

"We have the highest authority for making this statement. Recently a committee reported on this subject to the Prime Minister, by whom they were appointed. Their number included practical men and scientific specialists of the highest standing, and through the report which these gentlemen have made there runs the acknowledgement that the daily weather indications and storm warnings are well worth the money they cost; and they urge, further and especially, that the time has arrived for trying the efficacy of wireless telegraphy in providing advance news of the weather in the Atlantic. And the committee added, "We would urge that no unnecessary delay should take place in organising this experiment." Government departments, however move slowly, and pending their deliberations we have resolved to put the committee's recommendations to the test of practical experience."

We presume that this undertaking by the *Daily Telegraph* is but a beginning, and that an effort will be made to obtain weather reports from liners in other parts of the ocean. Isolated observations, although interesting, are not of much value, but if a number of observations are made over a wide area and carefully correlated with those received by the Meteorological Office, they will be of great service in forecasting the weather over the British Isles.

RECENT PUBLICATIONS.

Annals of the Astronomical Observatory of Harvard College. 43, part III. Observations and Investigations made at the Blue Hill Meteorological Observatory, Massachusetts, U.S.A., in the years 1901 and 1902, under the direction of A. L. ROTCH. Cambridge, Mass., 1903. 4to. 129 pp. and 5 pl.

This volume contains the daily meteorological observations made at Blue Hill Meteorological Observatory, and also three papers, viz.: "The Effect of Meteorological Conditions upon Audibility," by A. L. Rotch; "Results from the Kite-Meteorograph and Simultaneous Readings at the Earth's Surface, 1897-1902," by H. H. Clayton; and, "Kites and Instruments employed in the Exploration of the Air, at Blue Hill Observatory, 1897 to 1902," by S. P. Fergusson.

British Rainfall 1903. *On the Distribution of Rain over the British Isles during the year* 1903, *as observed at nearly* 4000 *Stations in Great Britain and Ireland, with Articles upon various branches of Rainfall Work.* Compiled by HUGH ROBERT MILL, D.Sc., LL.D. London 1904. 8vo. 67 + 300 pp. and 10 plates.

The first thing that strikes one on looking at this volume is the absence of the name of Mr. H. Sowerby Wallis, who has retired altogether from the work of the British Rainfall Organisation. From the year 1872, Mr. Wallis had been connected with the work, and his name has appeared on the title-page of each volume since 1890.

Dr. Mill is to be congratulated on the compilation of the present volume. He has taken advantage of the change in the editorship, to improve the orginal plan of the work, and also to introduce some new sections. Part I. remains practically unchanged. The special articles this year deal with "the three wettest years of British Rainfall," viz. 1872, 1877, and 1903; and "the Daily Rainfall of June, 1903."

Part II. has been greatly improved. The section Heavy Rain on Rainfall Days is illustrated by maps for each remarkable case of a widespread fall. New sections dealing with (1) Rainy Spells; the Intensity of Daily Rainfall; and (2) of the Number of Rainy Days, add a considerable amount of new matter. The full value of these additions cannot appear until they have been continued long enough to compare one year with another.

Monthly Rainfall is discussed in greater detail than formerly, and the maps are now on a larger scale and are accurate summaries of the variation from the average conditions in various parts of the country.

The number of complete rainfall records published in the volume are: 2847 for England, 265 for Wales, 502 for Scotland, and 215 for Ireland, the total being 3829, which is an increase of 193 on the previous year. The year 1903 was the wettest of the last thirty years, and very nearly the wettest on record, while for the neighbourhood of London, it was the wettest ever experienced as far back as continuous records of any sort extend, which is to about the year 1725.

The Rainfall for the year was:—

England and Wales .	43·81 ins.	Difference from Average .	+28 per cent.
Scotland . .	59·05 ,,	,, ,, .	+31 ,,
Ireland . .	51·11 ,,	,, ,, .	+24 ,,
British Isles . .	49·26 ,,	,, ,, .	+28 ,,

The largest rainfall during the year was 223·40 ins. at the Stye, Cumberland, and the least 24·16 ins. at Beachy Head, Sussex. The maximum fall in one day was 4·78 ins. at Ben Nevis Observatory on January 29.

Dr. Mill gives the names of a number of the observers whose names appeared in the first volume of *British Rainfall*, 1861, and who are still alive. This list tends to confirm the statement often made by Mr. Symons, *viz.* that meteorologists are long-lived. We know of one observer at least whose name has been omitted from the list, *viz.* Mr. E. P. Phillips, of Haverfordwest. Mr. Phillips commenced observing as long ago as 1849. It may be interesting to mention that the wettest period in Mr. Phillips' record is the following:—

1852.	October . .	5·60 ins.	1853.	January . .	6·12 ins.
,,	November . .	10·37 ,,	,,	February 1-3 .	1·80 ,,
,,	December . .	8·00 ,,			

a total of 31·89 ins. in 4 months and 3 days.

Cape of Good Hope. Report of the Meteorological Commission for the Year 1902. Cape Town, 1903. 4to. (192 pp. and pl.)

During the year 1902 the following stations were in operation, *viz.*, 1 First Order Station; 1 Subsidiary First Order Station; 58 Second Order; 27 Third Order; and 418 Rainfall Stations. The results from these stations are printed in this volume. Diagrams showing the mean monthly rainfall over each division, with the average number of days of rain during 1902, are also given.

Deutsche ueberseeische Meteorologische Beobachtungen. Gesammelt und herausgegeben von der Deutschen Seewarte mit Unterstützung durch die Kolonialabteilung des Auswartigen Amtes. Heft 12, 1904. 4to. 117 pp.

This volume contains the daily observations made at the following German Colonial Stations:—Uyelang (Marschall-Inseln), January 1894 to December 1897; Yaluit (Marschall-Inseln), March 1893 to December 1895; Nauru, October 1895 to December 1899; Apia auf Upolu (Samoa-Inseln), January 1896 to December 1899; Rarotonga (Cook-Inseln), January 1899 to December 1899; and Tsingtau, July 1899 to December 1901.

Ergebnisse der Arbeiten am Aeronautischen Observatorium, 1 *Oktober* 1901 *bis* 31 *Dezember* 1902. Von R. ASSMANN und A. BERSON. Veröffentlichungen des Königlich Preussischen Meteorologischen Institutes. Berlin, 1904. 4to. 274 pp. and 12 pl.

This volume gives in detail the observations made by means of kites and balloons at Berlin from October 1, 1901, to December 31, 1902. During this period 356 ascensions were made, the maximum height reached being 65,500 ft. The volume also contains two papers, *viz.*:—"Die Entstehung und Auflösung des Nebels," von H. Elias; and "Bericht über Drachen-Aufstiege auf der Ostsee, den Norwegischen Gewässern und dem Nordlichen Eismeere," von A. Berson und H. Elias.

Hourly Readings obtained from the self-recording Instruments at four Observatories under the Meteorological Council, 1900. Thirty-second year. New Series. Vol. 1. Published by the authority of the Meteorological Council. Official No. 163. London, 1904. 4to. 13 + 195 pp.

The present volume, giving the hourly values of the meteorological elements derived from the records of self-registering instruments at four observatories in the United Kingdom for the year 1900, is the first of a new series. For the thirteen years 1887 to 1899, volumes containing mean hourly values for each five days and for each calendar month have been published for the first order observatories of the Meteorological Office. To the tables of means, hourly readings for Kew and Valencia have been added to each of the last three years of the series.

For the year preceding 1887, mean results for periods of five days and for calendar months have been published in the *Quarterly Weather Reports* for the years 1869-1880, and in *Hourly Readings* for the years 1881-1886. The results thus published are derived from continuous records extending at four of the observatories over thirty-two years. At Fort William the instruments have been in operation since the year 1891.

In the present volume, hourly readings, with some auxiliary tables, are given for Valencia, Aberdeen, Falmouth, and Kew. The readings for Fort William

are in course of publication by the Scottish Meteorological Society, in conjunction with the hourly readings of the Ben Nevis Observatory. For the sake of convenience, the results for each observatory for each month are printed on a four-page sheet which can be had separately if desired.

It is intended, as soon as the arrears have been overtaken, to prepare the hourly readings for the press as soon as possible after the close of each month, and the sheets are accordingly paged so that the observations for the month from the four observatories come together; but the form of publication has been arranged so that the results for the several observatories can be grouped and bound separately by those who desire to deal with the observations in that manner.

Publications of the United States Naval Observatory. Second Series. Vol. 5. Washington, 1903. *Meteorological Observations and Results*, 1893-1902. 4to. 10 + 443 pp.

The first regular observations made at the new Naval Observatory, Georgetown Heights, are given in this volume. The observations as printed consist of the corrected readings of the barometer, dry and wet bulb thermometers, amount and form of cloud, direction and velocity of wind, together with the daily means of barometer, thermometer, amount of cloud, and velocity of wind.

The results are shown in tables as follows:—Table 1. Daily means of corrected readings of the barometer. Table 2. Extremes of corrected readings of the barometer at time of observation. Table 3. Mean daily temperature from dry bulb thermometer. Table 4. Amount of rain. Tables 5-6. Means and extremes of maximum and minimum temperatures.

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature*. .

Abbe, C.—The Importance of a Knowledge of Vertical Wind Components. *Monthly Weather Review, Washington*, **32**, 1904 (120).

Arrhenius, S.—On the Electric Equilibrium of the Sun. *Proc. Roy. Soc., London*, **73**, 1904 (496-499).

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